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A FORTIFIED CANADA

OUR PLASTIC CENTURY

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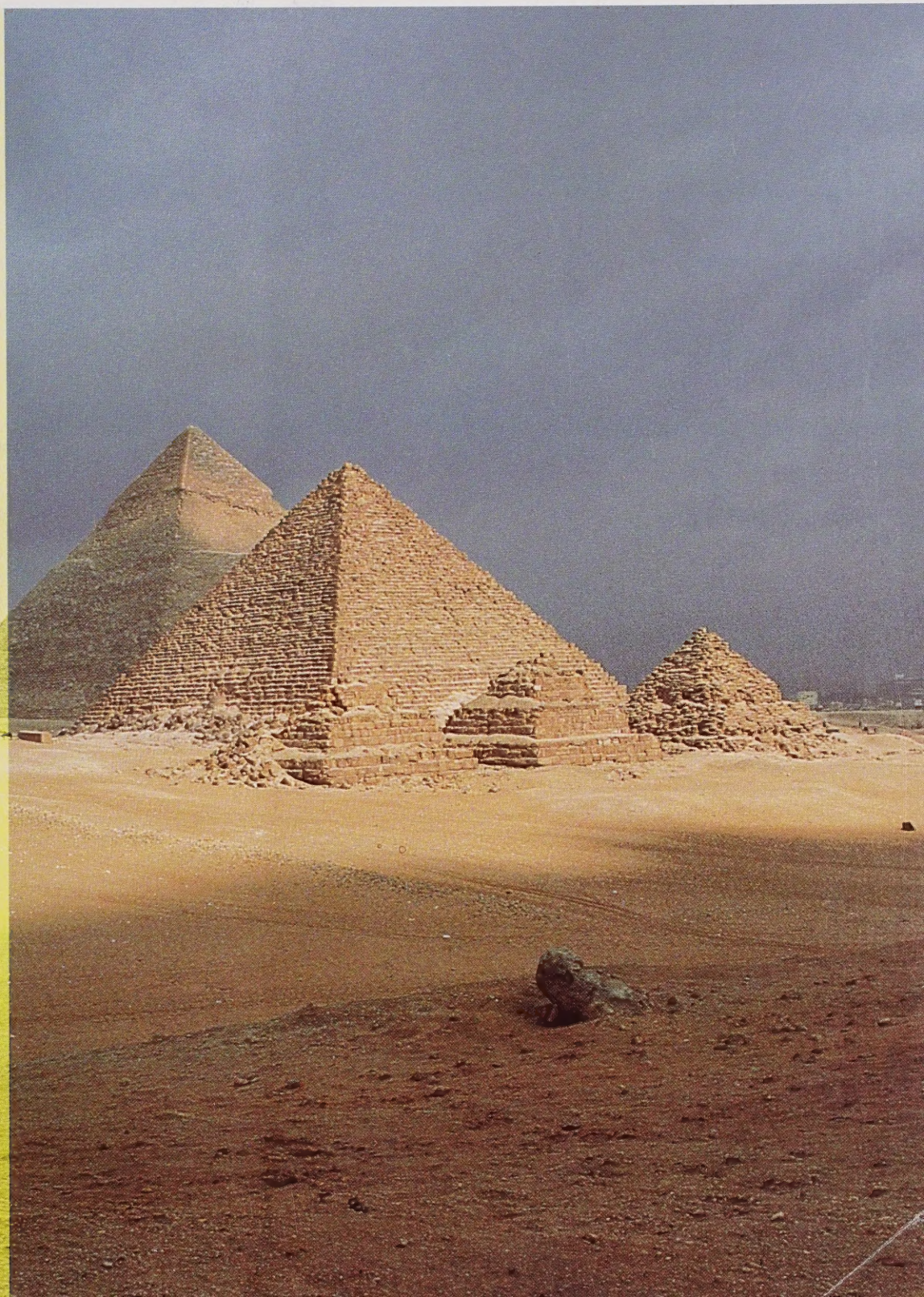

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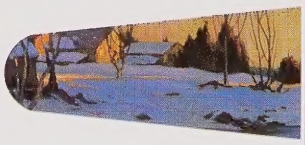
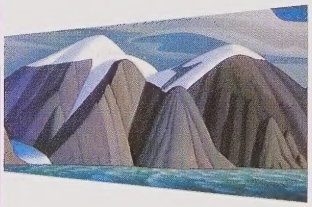
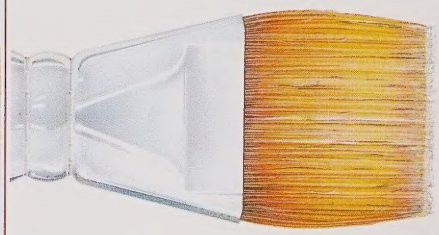


J.W. Beatty – 1869-1941



Lawren Harris – 1885-1970

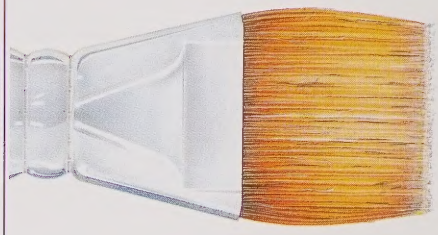
A.Y. Jackson – 1882-1974



Tom Thomson – 1877-1917

Franklin Carmichael – 1890-1945

William Berczy – 1744-1813



Paul Kane – 1810-1871

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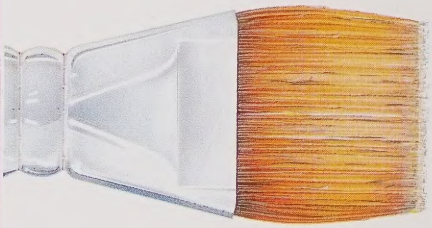
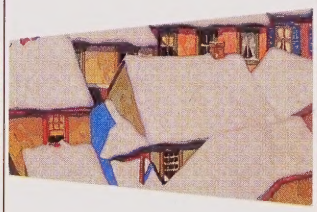


Arthur Lismer – 1885-1969



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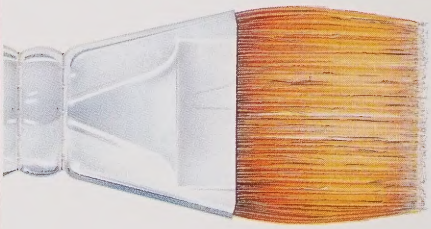
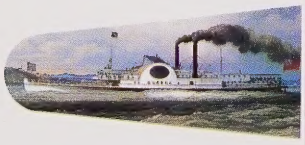
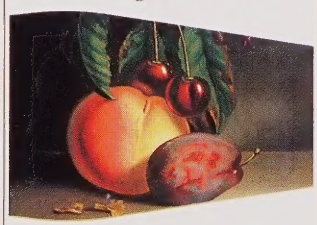
Clarence Gagnon – 1881-1942



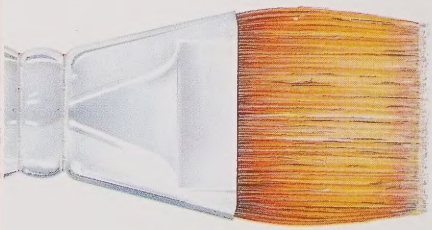


Cornelius Krieghoff – 1815-1872

James W. Morrice – 1865-1924



Robert C. Todd – 1809-1865



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(Date of issue: February 1990)

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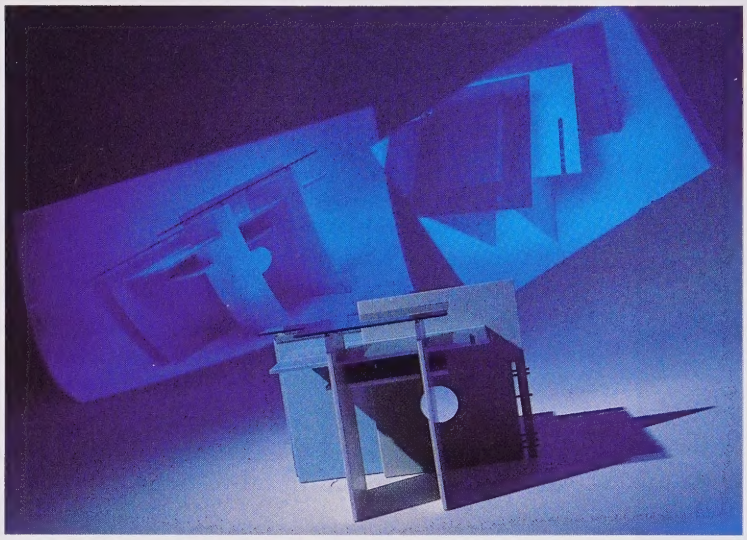

COVER
The pyramids and sphinx at Giza have to be one of the greatest public works projects of the ancient world. But who built them? To find out the answer to this question turn to page 36. Photo by Margaret Sears.

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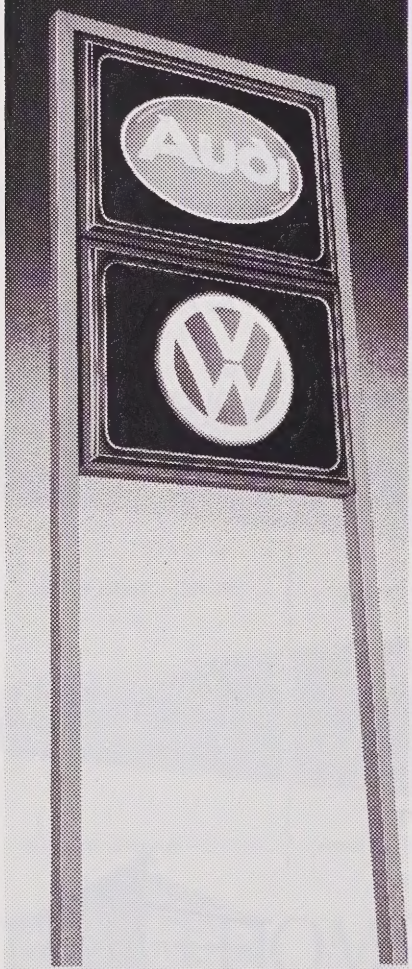

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EDITOR'S NOTE

AS A TEENAGER I WAS hooked on Egypt. I knew that I was destined to become an archaeologist. Disillusionment set in when, at the age of eighteen, I spent the month of July in northern Ontario on my first and last archaeological dig. Mosquitoes, black flies, and, worst of all, perpetually dirty fingernails, were not my style.

Mark Lehner of Yale University managed to rise above such mundane grievances to achieve what I and so many others only dreamed of. At Giza, one of the world's most famous archaeological sites, he is on the brink of discovering who built the mammoth project that included the Great Pyramid and the Sphinx. Margaret Sears, also of Yale, writes about the fieldwork to locate the workers' settlements.

On the subject of enduring achievements, for thousands of years the ancient Maya survived reasonably well in the rainforest, the same forest that is being cleared so ruthlessly today for agricultural land. Research shows that the human population in the rainforest of what is now Belize is about the same size that it was 4000 years ago. How did the ancient Maya agricultural society exist harmoniously with an environment that the modern agricultural society feels compelled to destroy? Although not conservationists in today's sense of the term, the ancient Maya, as ROM archaeologist David Pendergast explains, certainly had a special understanding of their surroundings.

Canadian forts should have the same importance to our culture as the monuments at Giza have for Egypt. But their survival and the recognition of their historical significance is often more comparable to the world's rainforests. Douglas Fetherling, a cultural historian, points out in his article that the struggle to save some of our forts has been an expression of indifference by Canadians to the fact that virtually all of this country's urban settlement owes its origins to forts.

Although the continuing existence of historical forts and rainforests is questionable, there is no doubt that plastic is one thing in our world that lasts. It has been the most popular material in the 20th century for the manufacture of everything from Bakelite jewellery to artificial limbs. As the result of a generous donation from Formica Canada Inc., the Museum can now update and supplement its collections through the acquisition of plastic artifacts in the same way that it has traditionally collected objects made of metal, glass, ceramics, and wood. Howard Collinson of the European Department describes some of the pieces in the Formica Canada Collection of Plastics.

We usually look around us for clues to understand our world. However, some scientists are looking inwards. They are examining the genetic makeup of mitochondria, small forms that may have first descended from bacteria billions of years ago, and that live in all cells that require oxygen. Popular science writer Jay Ingram explains how mitochondria are extraordinary keys to understanding the evolutionary process.

From reading about the builders of the monuments at Giza to the builders of life on this planet, enjoy this issue of *Rotunda*.

Sandra Shaul

Sandra Shaul

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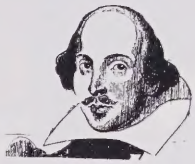

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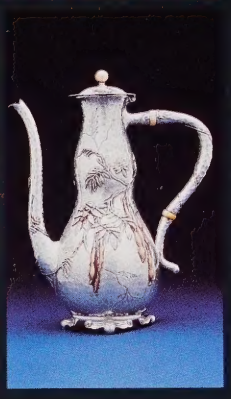

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CHRISTIE'S

Is conservation in Indonesia really possible?

Although I received several very positive calls about the article "Saving the People: Saving the Land," published in the fall 1989 issue of Rotunda *(Volume 22, no.2), some readers questioned the validity of Stephen Nash's conservation program in Irian Jaya, Indonesia, in light of the recent negative press about Indonesia. I also read some of the press accounts. A phone conversation with Stephen resulted in his sending me a long letter, which I have excerpted here, and a copy of the* World Wildlife Fund Letter, *no. 3, 1989, written by Roger D. Stone, about Irian Jaya. I was much encouraged by what I heard and read.*

EDITOR

Thank you for letting me know about the various reactions to the "Saving the People, Saving the Land" article. I am heartened by the positive reaction of some of your readers, who expressed agreement that conservation is for people, not just for wildlife. The article is not an attempt to make the fact of rainforest destruction in Indonesia seem less serious than it is. The article is about making the concept of conservation acceptable and desirable to the rural poor and to development planners.

It is the real and current threat of large-scale deforestation that makes efforts such as those undertaken by WWF in the Arfak reserve so important. Provincial and national governments in Irian Jaya and Indonesia respectively must be shown working examples of people-centred conservation, and people-centred development. To everyone involved, conservation must be demonstrated as a viable land-use option, and the benefits of conser-

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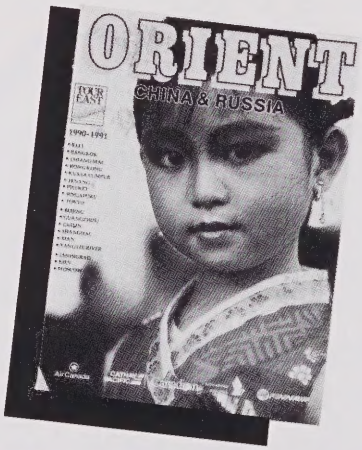

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vation in regards to social and economic development must be evident before we can make concrete gains. Once the true benefits and importance of conservation are recognized by decision-makers, we will have a better chance of succeeding in our battle against unsustainable development.

Approximately 20 per cent of Irian Jaya has been classified as "conservation land," some eight million hectares. Without the support of local people, conservation efforts usually fail. Support of conservation principles is obtained through education. Support of conservation action is obtained through economic incentives, such as butterfly ranching.

In addition to the Arfak reserve, we are supporting community-participatory management in two other areas, Cyclops and Cenderawasih Bay. ...These three conservation areas are progressing towards being self-propelled community-managed systems. We are beginning to expand our efforts to other conservation areas in Irian Jaya, but we are limited by human and financial resources, and the community-participatory management process takes time—there is no "quick-fix" solution. Our efforts require us to have a knowledge of tribal laws, culture and language, and economics, in addition to the natural sciences.

Recently I attended a workshop in which forestry development for the next five years was the main topic. In reply to a question from mining interests on which group has priority over land—mining, forest exploitation or conservation—the province's chief economist said, "of what use is having gold in your hand if you cannot breath." There is no doubt there will be a lot of mining and forestry exploitation in Irian Jaya in the near future, but if the province's development planners are thinking beyond sectoral interests to global environmental concerns, there may well be effective conservation too. It is not yet widespread, but the un-

derstanding that conservation and sustainable social/economic development are inseparable is gaining acceptance at important levels.

STEPHEN V. NASH
COORDINATOR,
IRIAN JAYA PROGRAMME

Do plastic polybags make *Rotunda* an ecological hazard?

I am a new subscriber to *Rotunda* magazine and I am very pleased with it. The articles are fascinating and well presented.

However, there is one thing that I would like to call to your attention. Why do you need to send your magazine through the mail wrapped in plastic? I feel this is environmentally unsafe.

I urge you to reconsider your mailing techniques. We should all be concerned with how we are affecting the world around us. After all, part of *Rotunda* is involved with investigating the past. Shouldn't we make an effort to leave a clean and interesting legacy for our future generations?

ALICIA DUTKA,
SASKATOON, SASKATCHEWAN

I would like to lodge a very strong complaint against your practice of mailing *Rotunda* in a plastic envelope. I realize that *Rotunda* is a beautiful magazine that you would like to protect, but I assure you that I would prefer a few wrinkled pages to more plastic.

KAARINA TALVILA,
VICTORIA, BRITISH COLUMBIA

We have received several letters such as the ones above that express concern over our use of plastic polybags instead of the paper wrap that we used to use for mailing the magazine. The concern is that the plastic polybags are non-biodegradable and therefore an environmental hazard.

Three ingredients are needed to cause any material made from organic matter such as paper to decompose: moisture, oxygen, and microbes. In modern dumps, the garbage is so compacted that little oxygen or moisture penetrates beyond a certain depth, so not even newsprint decomposes. Like newsprint, however, plastic bags are recyclable. They can be used to make insulation. Therefore readers of Rotunda *and other polybagged magazines should lobby to have their recycling programs include plastic wrap.*

You should also note that the so-called "biodegradable" plastic bags and wraps are not recyclable and they are not really biodegradable, although they are more expensive. Starch is added to the plastic, which microbes eat. As a result, the bag or wrap is broken down into smaller pieces of plastic, but the plastic does not decompose.

Polybagging allows the Museum to mail several of its publications together to the membership and thus reduce not only postage costs but also packaging materials and costs for each piece. This is a sound practice for a not-for-profit public cultural institution.

EDITOR

THE RENASCENT TREATMENT CENTRES

Treating the Billion Dollar Heartache

Alcoholism

Alcoholism is the number one killer in the world today. It destroys men and women of all ages without discretion. Families are destroyed, careers ruined and, without treatment, the only relief for the suffering alcoholic is a lonely degrading death.

Renascent, founded in 1970 is a non-profit organization dedicated to the treatment of those suffering from the diseases of alcoholism and drug abuse.

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An elegant piece of Duke Burton calcite from Tennessee and a large piece of dioptase, a copper silicate found in Namibia, are superb additions to the Museum's mineralogy collection.

PHOTOGRAPHY BY BRIAN BOYLE, ROM

THREE EXAMPLES OF MINERALS, which were recently purchased, are superb additions to the Royal Ontario Museum's mineral collection. The first is dioptase from the Tsumeb mine in Namibia. The finest dioptase in the world comes from this locality, and this is the biggest and best sample that the ROM owns; its purchase was made possible by the Future Fund Today—ROM Endowment.

The second is a particularly elegant group of calcite crystals from Tennessee. The crystals were purchased for the Museum in memory of Duke Burton, an avid collector of minerals, by his friends.

The third purchase is a beautiful group of clear, colourless quartz crystals from the Collins Quarry in Arkansas. This quarry is renown for its quartz deposits.

ROBERT GAIT
DEPARTMENT OF MINERALOGY,
ROYAL ONTARIO MUSEUM

Turn to page 21 to read about a new collection at the ROM.

Don't forget about the Royal Ontario Museum's "Gem of an Auction" to be held in May 1990. The auction, which is organized in conjunction with Sotheby's (Canada) Ltd., will raise money for the Museum's new S. R. Perren Gem Room. For further information about donations for the auction or the auction itself call Joyce McMeekin: (416) 586-8009.

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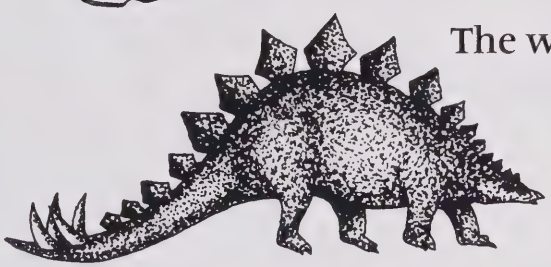

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PHOTOGRAPHY BY GLORIA VARLEY

The apple has many symbolic meanings and is used in many different ways by people around the world.

Eve's Apple

THE APPLE HAS A LONG HISTORY AS troublemaker. In the Garden of Eden, Eve blamed it for all her woes. For Paris, everything went wrong once he awarded that cursed prize. And never mind that the apple of the Bible and mythology was more likely an apricot, a pomegranate or a banana. It's good old *Malus* that has to take the rap.

But the apple has an opposite reputation, as well. Grandmothers swear that an apple a day keeps the doctor away; other traditions go further, claiming the fruit as a potent symbol of immortality. Obviously the common apple is more complex than its blandly uniform appearance in our supermarkets suggests.

Perhaps this very commonness gives rise to the wildly varying views of the fruit's potential for both villainy and virtue. *Malus pumila*, the particular species from which our varieties developed, originated in the Caucasus, somewhere between the Caspian and Black seas, and slowly spread outward until now it is grown on every continent, in conditions ranging from cool temperate to near tropical. Flourishing as it does in so many different places, with people of such widely varying cultures, the apple has come to carry diverse symbolic meanings and to be used in substantially differing ways.

The earliest apple wouldn't have much appeal for consumers today. Small, hard-fleshed, and sour, its wild descendants can still remind us of how much breeding has improved on the original material. Nowadays there are from 3000 to 7000 varieties in existence, depending which source you believe.

One reason for the flood of differing types is the fact that each apple seed planted will produce a distinct variety rather than a replica of the mother tree, a process governed by chance in the past, and by chance plus careful hybridizing in the present. To obtain exact duplicates, it's necessary to use vegetative propagation. The techniques for achieving this were already familiar to the ancient Greeks. Many of today's prized apples sprang from seeds sown once upon a time in someone's dooryard. If the resulting tree bore superior fruit, twigs, called scions, would be grafted onto other rootstocks and eventually the new variety would come into commercial production.

Ontario's most famous example was first discovered by John McIn-

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tosh on his Dundas County farm in 1796. One of its parents may have been Fameuse, carried to Canada by French soldiers, but whatever the source, the original Mac was propagated for a number of years, then finally introduced in 1870. It has now spread almost all over the world (one apple specialist tells of coming across it in a Kiev farmers' market), and has probably helped parent more new varieties—including Cortland, Empire, Macoun, and Spartan—than any other.

Apples certainly have diverse points of origin: Gravenstein in either Italy or Schleswig-Holstein (the stories vary); Cox's Orange Pippin in England; Granny Smith in Australia. The ubiquitous Red Delicious sprang from the rootstock of a tree in Iowa in 1880. The Golden Delicious, although similar in shape, is not genetically related. It occurred as a chance seedling in West Virginia in 1890.

Nutritionally speaking, grandma was only partly right with her apple-a-day maxim. Since they store well, apples did in the past provide valuable vitamin C after other natural suppliers had run out, and long before citrus fruits were available to cold-climate inhabitants. But the amount of the vitamin in an apple is minute compared to that in an orange, about 6 mg to 53 mg in average size fruits, which explains why ascorbic acid is usually added to commercial apple juice. Otherwise apples are mainly rich in carbohydrates (sugars rather than starch) and they're excellent sources of the soluble fibre pectin.

But they're not entirely benign. The seeds contain cyanogens and there have been cases reported of people roasting and eating a few dozen pips as an experiment, then dying of cyanide poisoning. Swallowing one or two won't do any harm but it's not to be encouraged.

Seeds notwithstanding, a fine crisp apple is a treat, especially when it's possible to find some of the less known, locally grown favourites. They may not be up to modern commercial specifications. Heavens, there may even be a blemish on the skin or more than a millimetre's difference in size between samples. Most people will happily ignore such "defects" and revel in the wealth of flavours and colours that can be had once the Delicious duo and Granny Smiths, useful as they can be, are left behind. Transparents are early pale green apples, mild and juicy. Tolman Sweets ripen late and are marked by a stitchlike pattern on the skins. Winesaps have a flavour that lives up to their name, while Jonathans taste sweetly of spice.

Many apples are also splendid cookers, ending up in all sorts of sweet or savoury concoctions, at any course from soup through dessert. Apple juice is simply processed, pasteurized cider (which is itself the pressed juice of fresh apples). Hard cider occurs when the sugars in sweet cider begin to ferment into alcohol. Apple brandy—the Calvados of Normandy being the most famous—is distilled from cider and shows its origin in its heady fragrance. (Apple brandies produced in North America, in contrast, often contain grain spirit as well as cider, presumably for reasons of economy, and so lack much of the distinctive perfume.) Applejack is traditionally produced by freezing hard cider: water freezes before the alcohol and is removed, and this process is repeated until a very potent liquor remains. Cider can also be turned into vinegar, an old-fashioned favourite once considered a cure-all for colds.

Apples have had more esoteric uses, too. The Greeks served them at the festival of Artemis, while a branch bearing buds, flowers, and ripened fruit, known as the Silver Bough, allowed ancient Celts to enter the land of the gods. Modern residents of Carhampton in Somerset still wassail two venerable apple trees that grow in the garden of a

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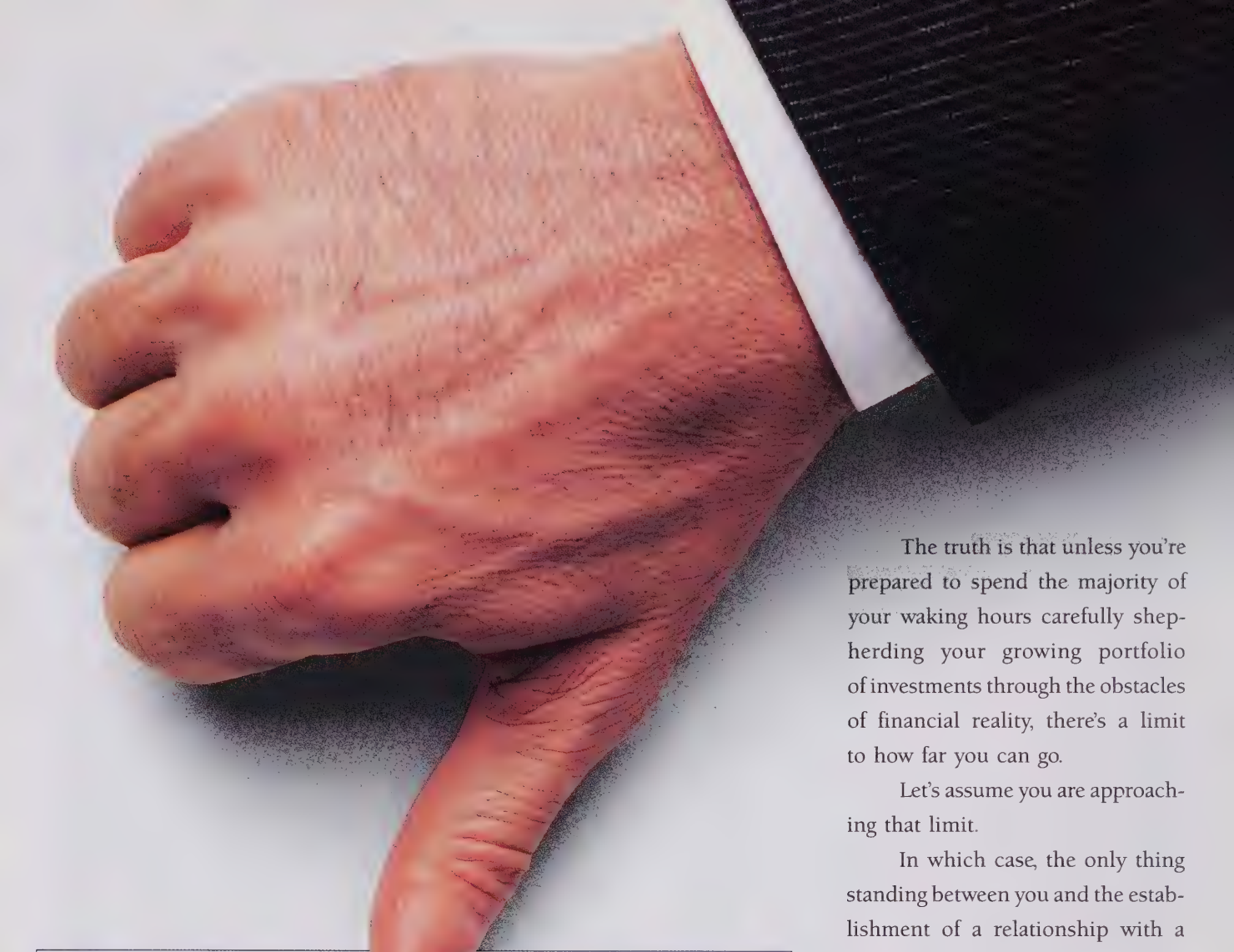

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local pub. Braving the January chill, men fire shotguns over the trees to ward off evil, while the publican's wife placates the good spirits—in this case, a bevy of robins—by tucking cider-soaked toast into a fork in the branches.

The following recipe isn't magical but it does provide a certain homely comfort to cheer raw winter nights.

Best Baked Apples

Ingredients

- 250 mL golden raisins
- 45 mL dark rum
- 6 large baking apples
- grated rind of 1 lemon
- juice of 1 lemon
- 90 mL red-currant jelly
- fine fruit sugar
- about 125 mL white wine, warmed
- cream or whipped cream (optional)

Method

• Mix raisins with rum and let stand for an hour. Then core apples and remove peel from upper third of each. Prick the peeled areas with a fork and rub with lemon to retard browning. Place apples in shallow baking dish. Add lemon rind and juice to raisins and stuff apples. Put 15 mL of currant jelly on top of each, pressing some of it down into the centre. Sprinkle apple tops with fruit sugar, pour wine around fruit, cover pan lightly with aluminum foil, and bake at 375°F for about 30 minutes or until just tender. Remove foil, baste apples with juices, sprinkle on a little more sugar, and return to oven until sugar melts. Repeat two or three times until tops are nicely glazed. Remove apples to serving dish, reduce juices (if necessary) to a syrupy consistency, and spoon over fruit. Serve warm or cool, with cream or whipped cream if you like. Serves 6.

GLORIA VARLEY, *a frequent contributor to* Rotunda *and other publications, is currently living in England.*

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A fragment of the top of a jar with a stopper that was found by the ROM team in Godin Tepe, Iran.

A Most Ancient Iranian Wine Jar

In the summer of 1973, Dr. T. Cuyler Young, Jr., and a team from the Royal Ontario Museum, completed excavations at Godin Tepe in northwestern Iran. Fifteen years later, in the summer of 1988, one of the oldest known Iranian wine jars was discovered buried among the thousands of sherds and objects brought back to the Museum's West Asian Department.

Godin Tepe had a climate well suited to viniculture and as a result it was a major grape-growing area. The common grape vine, *Vitis vinifera*, is thought to have been native to the Caucasian region between the Taurus Mountains of Turkey and the southern shores of the Caspian Sea in Iran, although it is now commonly found in the mountains of both Iraq and Iran.

Evidence for the earliest production and consumption of wine at Godin Tepe dates to approximately 3100-2900 B.C. (Late Period V), and it came from two rooms, designated 2 and 20, that looked onto a large courtyard. Room 2, located to the south of the courtyard, is best described as a workshop, where several objects, including the remains of one or two jars with relatively narrow and long collar necks, suitable for clay stoppers, were found. These objects suggest that wine was probably made in Godin at this time.

Each of the jars is decorated with a rope motif forming two "U" shapes along the lengths of opposite sides. For hundreds of years, rope decorations had indicated the placement of real ropes, which performed a useful function. For example, on Mesopotamian-type, four-lugged jars dating from an earlier period, the lugs are pierced and connected by a rope decoration that suggests real rope was used to secure a lid. Why did the rope on the Room 2 jars run lengthwise? Presumably it was so that the bottles would not roll if stored on their sides, a common practice when storing wine.

Across the courtyard in Room 20, two jars of identical style were found but the necks of both had been chipped away in ancient times. Once again, the explanation for the chipped bottle necks is probably related to wine. If the jars were sealed with clay stoppers (some clay stoppers were found in other rooms in the Godin complex), then to open a jar, its entire neck had to be chipped away so that no clay could contaminate the

contents. It would follow that the Room 20 vessels are the remains of used jars, whereas the intact bottles from Room 2 were fresh, unused jars. The destruction of the jars for the sake of their contents indicates the higher value placed on the contents.

One of the two jars from Room 20 is in Tehran and so cannot be examined. The other jar is the one found in the Royal Ontario Museum. It contains a distinct red sediment both on its bottom and along one of the sides with the rope decoration. Analysis of this sediment has been undertaken by Patrick E. McGovern and Rudolph H. Michel of the Museum Applied Science Center for Archaeology at the University of Pennsylvania Museum. Their research has provided positive identification of tartaric acid in the residue, a substance that occurs almost exclusively in grapes and grape products. In contrast, the unused jars from Room 2 contain no red sediment. It would appear that these jars are among the earliest known wine vessels from this region as well as some of the earliest found in the world, and that Godin Tepe was one of the world's first sites of wine production.

In addition to the used wine jars, Room 20 had a hearth and only used flint blades. There was also a complete necklace, the only one found at Godin Tepe, and one other luxury item, a fragment of a marble bowl. Whoever used this room was obviously well-to-do. Wine, a relatively expensive drink in ancient times, was much appreciated by the wealthy.

In Mesopotamia, the land of the Tigris and Euphrates river valleys so well documented on cuneiform tablets, the Sumerian sign for wine, GEŠTIN, appears very early on Jemdet Nasr Period tablets dating from around the beginning of the 3rd millennium B.C. Beer, rather than wine, was the drink for the masses, and in one Greek legend Dionysos flees Mesopotamia in disgust over the addiction of its people to beer. Unlike the climate of Godin Tepe, the climate in southern Iraq was not suited to grape growing and so wine was often imported from the north. "Wine in the north; beer in the south" is a familiar truism in the study of Mesopotamian beverages.

Mesopotamian rulers from Urukagina to Gudia and Nabonidus, as well as the Assyrian kings, enjoyed the northern wines. The inhabitants of Room 20 at Godin Tepe had an advantage over these mighty rulers: they did not have to import their wine. Rather they had bottles brought to them from across the courtyard.

VIRGINIA R. BADLER *is writing her doctoral dissertation on Godin V and the Chronology of the Late Uruk Period for the University of Toronto.*

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THE 20TH CENTURY IS PLASTIC

Dating from the 1920s are a bracelet designed by August Bonaz and a small box designed by René Lalique. They are made from celluloid, which was very popular at the time. The American "Cherries" brooch of the 1930s is a famous example of Bakelite jewellery.

PHOTOGRAPHY COURTESY FORMICA CANADA INC.

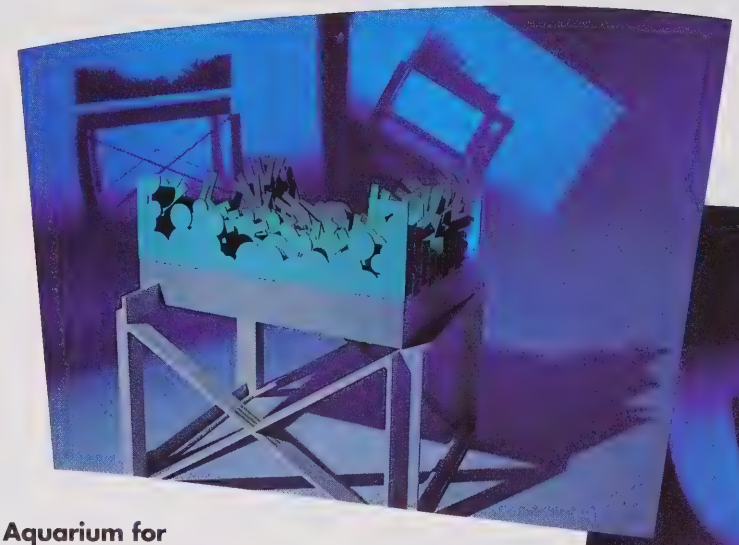
Has there ever been a more versatile material than plastic?

HOWARD COLLINSON

VISITORS TO THE SAMUEL EUROPEAN Galleries not only have a chance to become acquainted or reacquainted with the collections of armour and traditional furniture and decorative arts for which the ROM is so well known; they are also introduced to a completely new area of the collections: a variety of objects made from plastic. In 1988, Formica Canada made a generous donation to the Museum for the acquisition of a collection of approximately seventy-five artifacts, which document the history of plastic. No other material has made a greater impact on the production of goods in this century.

A broad range of plastics designed for different purposes is found in the Formica Canada Collection of Plastics. The first plastics were semi-synthetic materials such as moulded shellac and hard

Howard Collinson is assistant curator in the European Department, Royal Ontario Museum

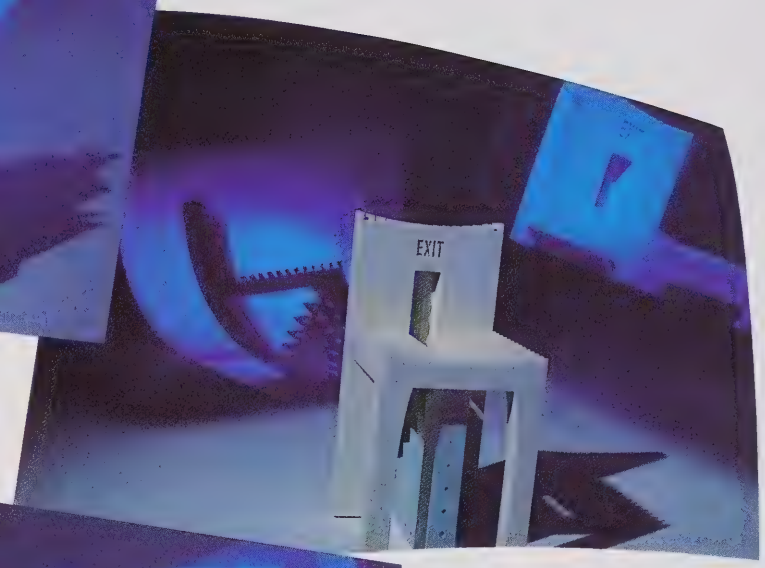


Aquarium for Frank Ghery's ColorCore Fish

Koen De Winter designed this piece as a complement to the well-known ColorCore fish designed by Frank Gehry. The wet environment is suggested by layers of laminated ColorCore wings. Viewed from one side, the colours suggest an underwater environment; viewed from the other side, the colours are desertlike and suggest a terrarium environment. The wings are mounted and supported by a base made of Surell, and the aquarium is mounted on a contrastingly light Surell structure reinforced with ColorCore.

According to De Winter, "Working with Surell is very much like working in marble. Polishing is probably the most exciting part of it....To see how a hard and strong material becomes smooth and visually soft is a wonderful experience."

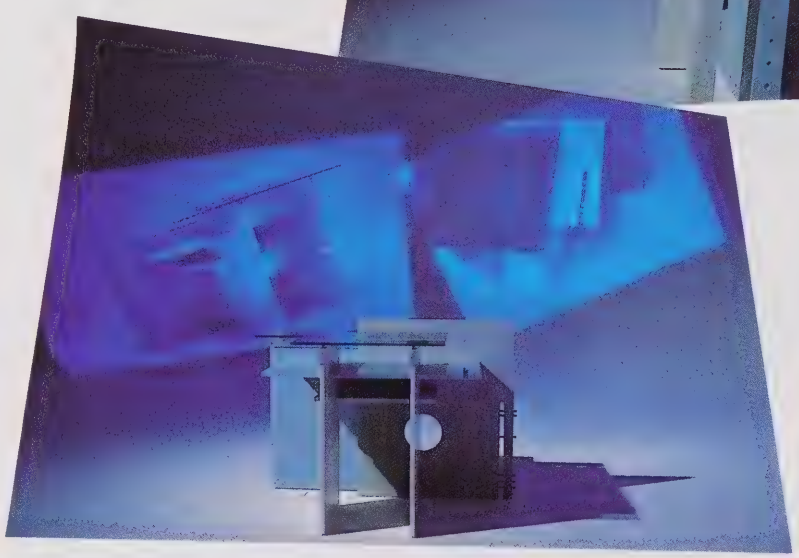
Koen De Winter is an industrial designer based in Montreal.



Exit Light

George Yabu and Glenn Pushelberg carefully studied the physical characteristics of Surell to make this piece. They were fascinated by how deceiving the look of the material could be. For example, it looks lightweight but in fact it is dense, and it can appear very luminous or as solid as stone.

George Yabu and Glenn Pushelberg established the interior design firm of Yabu Pushelberg in 1980 in Toronto.



Etagère

Peter Rose and William Steinberg explored the idea of layering in this piece.

They are architects with the Montreal firm Peter Rose Architect.

rubber, commonly used in the latter part of the 19th century. A photograph case made of moulded shellac, patented in 1857, is the earliest piece in the collection.

In the early 20th century, celluloid became the great rage. A group of French celluloid objects from the 1920s includes a small box designed by René Lalique and a bracelet by jewellery designer August Bonaz. Phenolic resin or Bakelite was another invention of the early part of this century. A splendid, footed bowl and a cup and saucer made from a version of this material called Bandalasta Ware show the brilliant range of colours that could be achieved in plastics. And no collection of plastic would be complete without Bakelite jewellery. There are five major pieces, including the famous American "Cherries" brooch from the late 1930s.

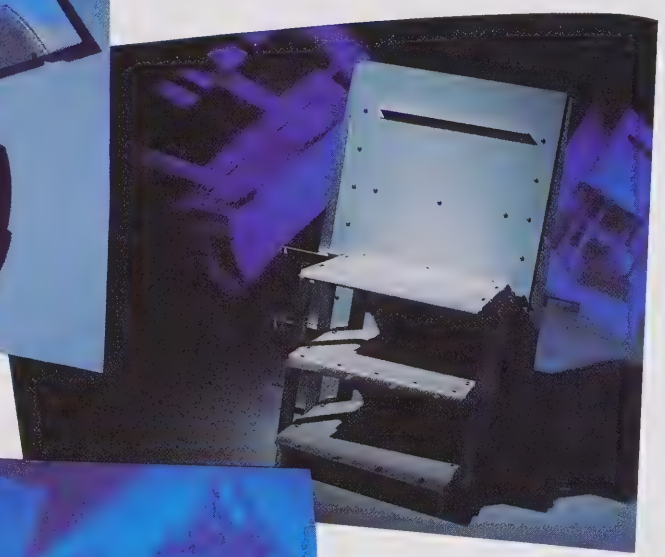
Newer materials are also included in the collection: acrylic, PVC, and melamine resin. Many people are surprised to discover that melamine tablewares (usually re-

Zero

Unlike the other artists, Del Terrelonge made a two-dimensional piece with a layering effect, using Surell combined with other elements to create a book within a book. The word "zero" has many meanings that are expressed in this work: figure O, nought; point on scale of thermometer, etc., from which positive or negative quantity is reckoned; zero-hour, the hour at which a planned operation, especially military, is timed to begin; crucial or decisive moment; zero in on, take aim at, focus attention on; zero-rated, on which no value added tax is charged.
Del Terrelonge is the principal designer of Terrelonge Design Inc., a graphic design firm.

Random Disorder

Michael Hosaluk created this "multi-level/position" sculpture that emulates many aspects of furniture design. The piece plays with the idea of tables within a table.
Michael Hosaluk is a designer/craftsman from Saskatoon.



Reference (Loveseat & Surfaces)

Thomas Lamb's name for this piece makes historical reference to Frank Lloyd Wright and Charles Rennie Mackintosh, two designers from the past whose work is very relevant to today's design. Lamb was fascinated by the way in which different surfaces can be created with Surell. He also took advantage of being able to prefinish parts before assembly.
Thomas Lamb is Canada's foremost furniture designer.

ferred to by the brand name Melmac) and plastic laminates such as Formica are made from the same materials.

Of special interest, given the Museum's objective of collecting the best work of contemporary design, is a gift of six pieces by contemporary Canadian designers commissioned for the ROM by Formica Canada. Using Surell, the latest plastic developed by the company, Koen De Winter, Peter Rose and William Steinberg, Del Terrelonge, Glenn Pushelberg and George Yabu, Thomas Lamb, and Michael Hosaluk, eight of Canada's most prominent designers, created these very innovative works.

The Formica Canada Collection complements and brings up to date the Museum's collections, which document mankind's many and changing designs for objects made from ceramics and other materials. There can be no question that the most important, most adaptable, and most commonly used medium for so many things in the 20th century is plastic.

THE MAYA HIGH FOREST:

CAN ITS PAST TEACH US ABOUT ITS FUTURE?

The Maya lived in harmony with the rainforest environment for 4000 years. How did they succeed where modern society has failed?

DAVID M. PENDERGAST

THE TROPICAL FOREST IS PROBABLY THE WORLD'S MOST MISLEADING ENVIronment. With such lush growth and such a profusion of species, the forest almost invites the callous denial that all the world's resources are finite. But the truth is that the rich foliage of the tropics owes its existence to highly developed specialization in conditions of thin soils from which nutrients are periodically leached by torrential rains. In recent years the forest in the Maya lowlands, as in other parts of the world, has taken on an additional misleading aspect. Seen in some places it appears virtually untouched, but behind that façade lies destruction on a truly massive scale. At Lamanai in Belize, for example, where we began excavations in 1974 with a vast extent of forest west of us, we saw the green carpet shrink at an ever-increasing pace year after year. Well before the project's end in 1986 the only remaining untouched forest stood within the archaeological reserve, a deceptive, thin green screen along the lake margin. Even in the reserve it was only our presence that gave some measure of protection to valuable trees and to the wildlife that had fled the cleared areas. The events of those years in the field often caused us to reflect on the difference between the ancient Maya attitude towards the forest and the attitude that is so pervasive in that land today.

The coastal forest stands behind "Temple B-4" in this aerial view of Altun Ha.

The ancient Maya knew full well that the delicate fabric of the tropical forest could not be handled roughly, or it would soon ravel. They knew this not because they shared our understanding of the natural sciences but because their religion taught them so. Though they saw the forest through eyes very different from ours, they sensed the

David M. Pendergast is curator-in-charge of the New World Archaeology Department, Royal Ontario Museum

fragility of their surroundings and organized their lives accordingly. There may not be many lessons we can learn from a people so separated from us by time and culture, but their attitude towards the environment was one that, in some respects at least, our society would do well to emulate.

A thousand years ago the lowland Maya would have spoken of their jungle setting as U Ka'anal Ka'ax Mayá, "the high forest of the Maya." That term scarcely seems fitting today, because there are so many places where there was once high forest and there is now only denud-

PHOTOGRAPHY BY DAVID M. PENDERGAST

ed land or scrub bush. There are many other places where the forest survives, but it is no longer in Maya hands and its fate is uncertain at best. Though some forest preserves have been created in Mayaland and moves are afoot to bring others into being, the area involved is only a tiny fraction of what the Maya once guarded as their domain. It is simple enough to understand how this has come about: the Maya forests owe their rapidly diminishing size in very large part to the rapa-

ciousness of Western society. But to comprehend the magnitude of the change that today's forest destruction represents, we must set the modern picture against that of the past and come to know how the ancestors of the modern Maya shaped their lives to the environment.

It would be foolish to believe that the ancient Maya, or any other ancient people, were conservationists in our modern sense of that term. Today the concern with resource conservation is altruistic; it rests on the efforts of individuals who may not benefit directly or immediately from their labours, and may indeed at times find their style of life adversely affected by the forces they set in motion. Though the ancient Maya were more attuned to their environment than most of us, their attitude had nothing of today's altruism about it. What at first glance seems an ancient Maya environmental awareness rather like that of modern conservationists was in fact something quite different.

A thin screen of remaining forest runs behind the planted and abandoned fields.

The Maya structured their existence around a set of responsibilities that were laid down by religion, but were born of environmental necessity. To keep themselves and their society alive, they worked almost constantly to ensure a positive relationship with the many gods who inhabited the natural world. The rupture of that relationship would, they knew, bring about a cataclysm much like what we foresee as the likely result of environmental degradation. Though they did not comprehend the forms and forces of nature as we do, they understood the natural (and the supernatural) world as a unified whole, much in the way that we see the tropics as a single, complex ecosystem. The most important difference between their view and the one that has dominated our recent history is that their religion did not give them dominion over nature, but rather made them part of it.

Dominion need not, of course, be an unlimited licence for irresponsible action, though most of our forebears have taken it to be just that, as many of our contemporaries continue to do. The Maya, lacking the Christian excuse to play fast and loose with the environment, believed themselves to be required to interact with the other elements in the ecosystem on an essentially equal basis. This meant that the system had to be recompensed when damage was done to the environment. Many modern Maya retain this reverent attitude towards the gods of the environment; for them, propitiatory offerings at the four corners and the centre of a field are as much part of agriculture as is work with axe and machete. Of course, recompense has never in itself guaranteed resource conservation; it has always had the form of offerings and ritual activity rather than reforestation or conscious management of food resources. Conservation

existed in the past, and may still be part of Maya life today, because religion identifies the natural environment as something to be used with care. This attitude may have been founded in Maya recognition more than four millennia ago that carelessness led to major degradation of the forest and decimation of its animal inhabitants.

Through the creation of systems to maintain high nutrient levels and adequate water supplies for the fields, the Maya developed soils that are still extremely rich, a thousand years after abandonment. Unfortunately today, uncontrolled clearing of the forests is threatening the land

The Maya were long thought to have shouldered a heavy burden in attempting to wrest a living from the tropical lowlands, and to have wrought great destruction to the forests in the struggle to produce food. This view was founded on our belief that the great Maya cities were supported by shifting slash-and-burn agriculture of the kind practised in the lowlands today. Debates raged for many decades over the issue of this seemingly insubstantial underpinning for a great society. Many envisioned shifting cultivation as a sort of gigantic mowing machine that would in short order have made life hazardous or impossible by levelling the forest round every large community. Forced to rely on shorter and shorter fallow periods on land renourished by second-growth forest alone, the people would have had to find either new methods or new land in order to survive. To some scholars, forest destruction seemed very likely to have been a main contributor to the death of Maya civilization.

In the past twenty years our understanding of ancient Maya agriculture has changed. We now know that Maya cities and towns were supported by irrigated raised-field systems. In some areas the fields stretched over several thousand hectares to create produce centres far superior to what one finds there today. This discovery means, first of all, that we no longer need to model ancient land use on the slash-and-burn methods encountered by the Spaniards in the 16th century and still in use in the lowlands today. Some clearing of relatively small patches of forest for planting was surely carried out, and market gardens are very likely to have been important in every community. The basic food supply system was, however, as complex and far-reaching as any that has existed in the Maya lowlands in modern times.

The ancient Maya conserved major portions of their high forest by recognizing that better land existed, or could be created, elsewhere. Superior production could be ensured with intensive cultivation of relatively small areas, including some—such as extensive shallow swamps—that had little if any other economic value. The critical elements in the system were maintenance of high nutrient levels and adequate water supply. The Maya attained these goals by seeing the two matters as one: the organically rich muck removed during cleaning of canals was deposited in the most convenient place, atop the fields. The result was soils that in some places are richer than surrounding land even now, a thousand years after abandonment.

From the lagoon it appears that virtually pristine forest conditions exist. In fact very little forest still stands.

To keep the system running smoothly and to distribute its products must have required extensive administrative effort. With the 10th-century breakup of the authority structure at most southern lowlands Maya communities (the well-known "collapse" of the society), the system seems to have been shorn away. As a result, shifting cultivation, once a comparatively minor element in Maya economy, came to the fore. In a sense it was fortunate that the change came at a time when the collapse of cities had set people on a course outwards onto the land. Because agriculture was no longer required to feed concentrated, non-food-producing city dwellers, the effects of slash-and-burn were far less worrisome than they would have been in earlier centuries.

Whether in raised-field or in shifting agriculture, the Maya approaches to the land surely never brought about the sort of destruction that goes on apace today. This was not because the ancient people were fewer in number than the modern inhabitants of the lowlands.

The size of today's population is probably fairly close to that of ancient times, though its distribution has changed, and almost all of the ruined great cities now have no residents. What made the Maya use of their forest resources less ruinous was their technology, in combination with their beliefs. If they needed to clear an area, they simply removed the forest with axe and fire. Trees of certain species, which were important for religious or economic reasons, were left untouched, as they are in Maya fields today. Thus the Maya preserved situations in which regrowth of the forest was at least possible because the earth, the most fragile element in the tropical system, remained essentially undamaged. It is the bulldozer and indiscriminate chain-clearing that not only deprive the soil of its protective cover but also break up its surface. With its defences against tropical downpours gone, the earth soon succumbs, and the rivers and the coastal sea run brown.

Leaves are gathered for making roofs. Only the leaves are cut; the trees are left standing to grow new leaves.

What of the great ancient cities, where the Maya did effect major change in the natural environment? If we look at the ruined centres today we see them clothed in a forest that seems, to the untrained eye, virtually identical to that in the rest of the lowlands. In fact, some species of vegetation are more numerous on and around ancient buildings than they are in nature, whereas others are less common. Some scholars have suggested that the prevalence of certain species, particularly breadnut (ramon), is evidence of Maya silviculture, but the truth seems to be that through building and other activities the Maya unintentionally created attractive spots for lime-loving plants. In places, especially along the coast and on islands, the whole plant community appears to result from ancient human presence. To many the fact that huge trees and thick undergrowth populate places that were once teeming with Maya life is reassuring; it must mean that even if an area is stripped bare, they will soon see the forest return. They forget, however, that present practice differs widely in scale and in technique from that of the past. Hence the lessons we think we perceive in the modern forest are no guide to what we will face if the tide of mechanical destruction is not stemmed.

As I have said, there are encouraging signs of concern on the part of governments and individuals in the countries that comprise the ancient Maya homeland, but the steps taken thus far scarcely begin the long journey towards the preservation of the forest resources that the Maya managed to husband through so many centuries. Perhaps because the Maya thought of those resources as a set of living forces embodied in gods, their handling of the natural world was far gentler than ours. It has ensured their survival, albeit not with the richest of lifestyles in recent times, for more than 4000 years. When Maya society collapsed, it was not because of wanton destruction of the main resources on which city life depended. We would be well advised to ask ourselves whether the same will be said of our society by the scholars—if indeed there are any—who come after us.

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MITOCHONDRIA
KEYS TO EVOLUTION

Some scientists now believe that minute forms found in all living organisms that require oxygen are crucial for the evolution of life on Earth

JAY INGRAM

ALMOST ALL OF OUR IMAGES OF ANCIENT LIFE HAVE BEEN created by fossils: a leaf or an insect wing pressed into a rock surface, a giant dinosaur leg bone, even a single tooth of an ancestral hominid. Today though, biochemists, not fossil hunters, are illuminating the past, and they're doing it by analyzing mitochondria—sausage-shaped organelles that are stuffed into the cells in your body like raisins in a Christmas cake. The quadrillions of mitochondria in your body use the oxygen from the air to burn food and yield energy, but they also shed light on the origins of human beings, even the origins of life itself.

Twenty years ago, mitochondria were known as the "powerhouses" of the cell, nothing more. Give them oxygen and sugar molecules, and they'll give you back water, carbon dioxide, and energy. Pick up any 1960s book on mitochondria, and you'll find chapter after chapter concerned only with the details of energy generation from food molecules. There's no doubt they are beautifully adapted for this role: in insects like flies and locusts, mitochondria actually grow and divide in anticipation of the tremendous energy demands of flight, and in some cells—in the kidney, for example—they migrate to those places in the cell where they're needed most. There is even beauty in the way an individual mitochondrion is organized for efficiency, with protein molecules imbedded in its inner walls like paintings in a gallery, spaced precisely so that electrons liberated from dismantled sugar molecules pass sequentially from one protein to the next, occasionally spinning off energy.

But no matter how intricate these pre-1970 mitochondria were, they were really nothing more than cellular factories, precise and efficient, with all the beauty and charm of an assembly line. Now, however, molecular biologists have turned mitochondria into time machines, and they are beginning to reveal—in unanticipated detail—crucial events in the evolution of life on Earth.

The first revelation has been the origin of the mitochondria themselves. Most scientists are now convinced that mitochondria are actually invaders that committed an act of biological break-and-enter—perhaps a billion years ago—and never left. At a time when life on Earth was still single-celled and confined to oceans and tidal pools, some predatory bacterial cell invaded a larger cell. For reasons that may never be known, it settled down there, and today has descendants inhabiting all the cells of all the organisms on Earth that use oxygen. Only certain extremely specialized single-celled protozoans, like those living in the depths of a termite's gut (where there's no oxygen at all), can get along without mitochondria.

Most scientists are convinced that mitochondria committed a biological act of break-and-enter, perhaps a billion years ago, and never left

It was about a hundred years ago that microscopists first suggested that mitochondria bore such close resemblance to free-living bacteria that they might even be related. It was no more than a suggestion: resemblance doesn't prove an ancestral relationship, any more than the observation that the east coast of South America fits the west coast of Africa proves continental drift. But guesses are occasionally right: belief in continental drift is now unanimous, and belief that mitochondria were once bacteria is heading that way. However, both ideas struggled for

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PHOTOGRAPHY BY LARRY OSTROM. ART GALLERY OF ONTARIO

Alfred Pellan, ***Femme D'une Pomme****, 1943,*
oil on canvas, 161 x 129.7 cm.
Collection of the Art Gallery of Ontario, gift of
Mr. and Mrs. Charles S. Band, 1956.

decades, and even though Soviet, German, and French biologists in the 1920s believed that mitochondria and other cellular "organelles" had invaded and stayed, they were ignored, even derided. The problem was lack of data: all the believers had going for them were some cellular look-alikes, and a lot of faith.

Today the picture is entirely different. After being out of fashion for decades, the symbiosis idea was finally revived in the late '60s by Lynn Margulis, a biologist at Boston University. The revival was stimulated in part by the discovery in the early '60s that mitochondria had their own genes, that is, their own DNA, completely separate from the main holdings of DNA in the nucleus of the cell. One of the most sensible ways of accounting for those extra genes was to suppose that they had once belonged to a bacterial ancestor.

Not only do mitochondria have their own genes and retain the capability of dividing, but the molecular machinery that builds new mitochondrial parts is bacterial in design, different in shape and size from the machinery in the rest of the cell. The arrays of molecules built into the mitochondrion that generate energy are more like those in some bacteria than in any other cells. Even the mitochondrial genes are arranged the way they are in bacteria, in a single loop of DNA.

Researchers like Michael Gray, a fellow of the Canadian Institute for Advanced Research at the Dalhousie Medical School, have painstakingly dissected, molecule by molecule, the DNA code sequences that program the building of the mitochondrion and have shown that they must have come from bacteria. For even though the mitochondrial invasion happened more than a billion years ago, and mutations have been changing the sequences steadily ever since, there is still more than enough similarity between bacterial and mitochondrial DNA to show that the mitochondria were indeed free-living bacteria at one time. It's a little like discovering two apparently unrelated computer programs which, although they have been altered, edited, and reworked for years, have so many lines of code the same that they must have been, at one time, the same program.

There's even a modern candidate for the original invader: an otherwise unprepossessing bacterium called *Paracoccus denitrificans*

There's even a modern candidate for the original invader—an otherwise unprepossessing bacterium called *Paracoccus denitrificans*. A plain soil-dweller, it seems to resemble the mitochondrion more than any other living bacterium, particularly in the way it generates energy. Of course *Paracoccus* is a billion years removed from the original mitochondrion and so cannot be identical to it, but it's the closest thing we have.

No one is likely to see *Paracoccus* sneaking inside a cell and taking up permanent residence. But a few years ago an event took place in a Tennessee lab that might have been a near replay of the type of cellular invasion that gave us our mitochondria. In 1966 Kwang Jeon, a scientist at the University of Tennessee, had ordered a new shipment of amoebae for study. Amoebae are jellylike, one-celled animals that move by oozing, and Jeon had been maintaining colonies of them for twenty years.

Soon after he had established the new amoebae, he discovered to his dismay that all the amoebae—old and new—were becoming sick. They stopped flowing smoothly and became round and granular, stopped eating and dividing, and started dying. Jeon noticed that the affected amoebae contained small dark objects, which turned out to be rod-shaped bacteria—up to 150,000 of them in each amoeba. These bacteria, possibly brought in with his new batch of cells, were killing almost all the amoebae they came in contact with. But a few of the infected amoebae did cling to life, and Jeon, by nurturing the most vigorous of them carefully, managed to persuade these infected amoebae to return to a relatively normal life cycle. But it took years, and hundreds of amoeboid generations.

Then Jeon made an amazing discovery: he found that those cells which survived even though harbouring the bacteria had, in accommodating to the invaders' presence, lost some of their biological skills. They couldn't survive without some chemicals that the bacteria were providing. And while it's true that these bacteria are not fully integrated into the fabric of the cell as mitochondria are, it is striking that they could, in just a few years, become essential for the survival of the amoebae. Why did only some of the amoebae live through the first onslaught of infection? What was the key event that transformed the bacteria into residents essential to the amoebae? If these questions could be answered, it might shed some light on the original mitochondrial invasion.

Mitochondria have lived inside cells for so long they are incapable of an independent existence (in fact, the erroneous claim made by the American biologist Ivan Wallin in the 1920s that he had grown mitochondria outside cells was one of the great setbacks for this whole area of research). They're double-wrapped in membranes, but they only make the inner one. The cell makes the outer. They have only 37 genes compared to the approximately 100,000 in the nucleus of the cell, so it's not surprising that they depend on the host cell to make many of the proteins they use. (It is the cellular version of a satellite economy: ninety per cent of the materials the mitochondrion needs are manufactured under the direction of the DNA in the cell's nucleus, and then shipped to the mitochondrion.) Yet trivial as their numbers are, these mitochondrial genes have begun to revolutionize thinking about human evolution.

The "molecular clock" is a method of estimating evolution's pace. It is possible to analyze the details of DNA from two different species and infer, from the degree of

J. W. G. (Jock) MacDonald, ***Nature Evolving****, 1960, oil on canvas, 111.8 x 137.2 cm.*
Collection of the Art Gallery of Ontario, purchase Peter Larkin Foundation, 1962.

difference, how long those species have been living separately. To put it another way, those differences tell you how far back in time you have to go to find the common ancestor of those two species. A rough analogy would be if you and a friend sold a jointly owned car and then each simultaneously bought a new one. The number of nicks and scrapes those two new cars accumulated over time would be a rough measure of how long you had been driving separately. Substitute mutations in DNA for fender-benders and you have an idea of the working of the so-called molecular clock.

The differences between chimpanzee and human DNA, for example, suggest that five million years have passed since we parted company with the chimp line, and that there was an animal living about five million years ago that gave rise to both humans and chimps. Changes—mutations—in the genes in mitochondria appear about ten times faster than they do in the genes in the nucleus of a cell, making the mitochondria an evolutionary quartz timer to the nucleus's sundial. Mitochondrial mutations can reveal to scientists very recent evolutionary splits where other methods can't.

In addition, mitochondria are only inherited through the maternal line. At fertilization, the sperm contributes its nuclear genes but no mitochondria—the only mitochondria present are those in the egg. This means that all the mitochondria in all your cells came from your mother. And if you're male and have only brothers, your mother's line of mitochondria is finished, unless one of her sisters has female offspring. Mitochondrial DNA is therefore a clean record of inheritance, unlike the genes in the nucleus, where female and male genes are mixed by fertilization in every generation.

A team from the University of California at Berkeley has used mitochondrial DNA to examine human evolution, with dramatic results. They compared mitochondrial DNA from 147 women from all over the world. When the relationships among all these DNAs were plotted, a novel human evolutionary tree emerged. First it seemed that there are two groups of people in the world: one including people from all continents who can be traced back ultimately to an African origin, and a second group—all

modern Africans—whose ancestors apparently never left that continent.

The other result of the study, the one that made headlines, was that all living humans can trace their ancestry back to one female. She lived in Africa roughly 200,000 years ago, and naturally enough she has been named Eve.

It is difficult to believe that the entire modern human population could be traced back to one woman, but mitochondrial inheritance makes it possible. Any time a woman produces only male offspring, her mitochondria stop there. Even if there had been thousands of women living and reproducing in Africa 200,000 years ago, as the generations passed, fewer and fewer lines of mitochondria survived. Today, only one woman is so represented among us. (At the same time there must have been females who gave birth to male offspring who have living descendants, but at the moment we have no way of tracing them.)

The idea that there was an Eve has more than just curiosity value. What are we to make of Java man and Peking man, fossil hominids who have always been considered good candidates for human ancestors, but who lived hundreds of thousands of years earlier? If everyone living today can be traced back to Africa just 200,000 years ago, then those earlier Asian hominids are irrelevant. Their descendants might even have been among the peoples swept aside by the flood of emigrants from Africa. Fossil bones and stone tools suggest that by 40,000 years ago these physically modern people of African origin were in Australia, and by 12,000 years ago (some say much earlier) in North America. Everywhere they went they took Eve's mitochondria with them. What was it about this group of early humans that enabled them to settle the world, even where there were already existing pre-human populations?

The idea that there was an Eve has more than just curiosity value. What are we now to make of the fossil hominids Java man and Peking man?

Allan Wilson, leader of the Berkeley team, has a radical answer for that question. He thinks that a mutation in mitochondrial DNA led to the ability to speak, and the group of humans that emigrated from Africa (including the descendants of Eve, if not Eve herself) possessed that mutation. Wilson reasons as follows: these African people presumably had some advantage over the indigenous hominids that they encountered as they moved around the world. Some recent research from Stanford University suggests that when the evolution of languages is compared to the genetic evolution of humans, there's a match: the linguistic family tree is the same shape as the genetic family tree. Wilson takes this to mean that modern humans and language had the same starting point.

It seems an enormous leap to suggest, as Wilson does, that a subtle alteration in mitochondrial genes could produce speech. How could a single gene mutation be responsible for an act of such complexity? And if that change appeared in mitochondria in every tissue and organ throughout the body, why would it affect only those parts of the brain responsible for speech? To that latter question there is at least a partial answer: there is some evidence that defects in mitochondrial genes may be very selective in their effects.

In the spring of 1989, researchers at Emory University in Atlanta published a report showing that a rare form of human blindness, Leber's hereditary optic neuropathy, is the result of a single mutation in mitochondrial DNA, which disrupts the mitochondrion's ability to generate energy from food. But while you might expect that disruption to cause multiple health problems for those who inherit such compromised mitochondria, the impact is targeted on the optic nerve; moreover, it doesn't show up until adulthood. In addition, Leber's hereditary optic neuropathy is by no means the only mitochondrial disease, and most of the others have specific organ targets as well, causing such disparate conditions as dementia, deafness, cardiac defects, even short stature. This at least supplies circumstantial evidence that a mitochondrial mutation can target a specific part of the body—even the brain. Allan Wilson's suggestion that a single mutation created speech may not be as far out as it seems.

Wilson also has one subtle piece of circumstantial evidence in his favour. Imagine an encounter between the people with speech emigrating from Africa, and a non-speaking band of early humans. If matings between these two groups followed a pattern commonly seen in history, in which males of the dominant group mated with females of the other, but not vice-versa, then males with the ability to speak would mate with females who couldn't. But because mitochondria are only transmitted by females, such matings would not spread the mitochondria that conferred the ability to speak. Language would then remain the property of the group coming out of Africa, because they would not be spreading their mitochondria. Had language been encoded in the genes of the cell's nucleus, then any cross-matings would have produced offspring who could speak, and the African group would have lost its linguistic advantage within a few generations. That they didn't seems to suggest that we are all descended from them.

Allan Wilson would be the first to admit there's little actual data for his ideas, but regardless, they stimulate our imagination. Who could have dreamt that tiny bodies floating inside our cells could have painted scenarios of the migration of modern humans out of Africa 200,000 years ago? For that matter, how humbling it is to realize that the bacterial invasion of some anonymous host cell more than a billion years ago was a milestone in our history. The analysis of mitochondria may be the start of a new wave of biochemical palaeontology, in which the fossils are gene sequences excavated from our own cells.

J. W. G. (Jock) MacDonald, ***Heroic Mould****, 1959, lucite 44 on canvas, 182.9 x 121.9 cm.*
Collection of the Art Gallery of Ontario, bequest of Charles S. Band, 1970.

Who Built the Great Pyramid of Egypt?

Archaeologists want to know who planned and built the legendary mammoth public works project at Giza

Margaret Sears

This mud seal impression carries the name of King Mycerinus, builder of the Third Pyramid.

"If Herodotus is right, and there were 100,000 workmen out here building the pyramids, their numbers would have constituted a 'super-city' by the standards of ancient times." Mark Lehner pauses a moment and reaches for a drawing of the Giza plateau to help illustrate the point. "What we are trying to do, basically, is to find this workmen's city—somewhere out there on the plateau—no matter what size it turns out to be. The people who built the pyramids have to be there—archaeologically speaking—at least what remains of their homes, their ovens, their pottery, and even their beer."

Lehner and a team of colleagues from Yale University spent two months last winter in Egypt excavating two sites, looking for evidence of settlements on the Giza plateau. Their work was the first season of an ambitious project that will be carried out over a period of five to ten years during which the multi-faceted team will attempt to answer some important but basic questions about the work force that constructed the pyramids. The team includes not only archaeologists, but specialists in plant remains and seeds, bones, and even a stone-sculptor from England who has worked on many of the world's greatest cathedrals. The team's Egyptian colleagues include co-director Zahi Hawass, the Director General

Margaret Sears has an M.A. in Near Eastern Studies from Princeton University. She served as the U. S. coordinator for the Giza Plateau Mapping Project and has been the project photographer since 1984.

The town of Nazlet es-Samaan crowds up against the plateau where the pyramids are found.

PHOTOGRAPHY BY MARGARET SEARS, YALE UNIVERSITY

for Giza and Sakkara of the Egyptian Antiquities Organization, and a hand-picked group of Egyptian inspectors and archaeologists.

As Lehner explains, the excavations this past season got underway after many years of careful planning and prior study of the plateau. Lehner himself is a veteran of Egyptian excavations. He spent over thirteen years in Egypt working on various archaeological sites all over the country, and for five years, beginning in 1979, he headed the first archaeological study of the Great Sphinx. During this work at the Sphinx, Lehner observed more closely the relationship of the monuments, such as the pyramids and quarries, to the physical layout of the plateau, and from his observations he saw the need for a project that would take a broader perspective of the plateau than had been taken by most Egyptologists.

Traditionally, archaeology at Giza has been a kind of "Who's Who" history rather than a broad focus on the socio-economic factors that shaped that history. Egyptologists, over a span of nearly two hundred years, have concentrated on the tombs, pyramids, and temples of Giza, as one might expect. From this work they have learned a great deal about the magnificent art and inscriptions of the 4th-dynasty Egyptians, and also a lot about the royal elite who supervised the building of the pyramids—their names, family relationships, and titles. Designations like "Overseer of the King's Works" or "Chief of (a group of) Ten" provide tantalizing insights into the way these officials were organized.

Nowadays, however, archaeologists are interested in investigating sites that lead to a better understanding of the society as a whole. Lehner explains: "In the case of the workmen's settlements, we are intrigued not just because we want to know more about the people who lived in them. We also want to know more about how Egyptian culture arose, how its resources were managed, and what it took for the Egyptians to plan and execute a public works project the scale of which had never before been seen in ancient times. To answer these questions, the aim is to excavate the houses and neighbourhoods of the average person, and to save every scrap of evidence."

Mark Lehner's quest for this new perspective began in earnest several years ago when he and David Goodman, a surveyor with CALTRANS, the California Transportation Authority, started to survey the entire Giza plateau in order to put together the first comprehensive topographical map of the site. From this work, Lehner learned more about the natural geological patterns of the plateau and the limitations the ancient Egyptian engineers must have faced as they planned their magnificent monuments.

The landscape tells the story of how the whole site was organized. Pyramids stand high up on the plateau, and the Great Sphinx sits lower, to the southeast of the Great Pyramid. From each pyramid a colossal ramp would have led downwards and out to the quarries where the bulk of stone for the buildings was extracted. The quarries themselves covered an area of approximately 2.7 million cubic metres. Beyond the quarries to the southeast, just past the Sphinx, lay a harbour where stone was brought from sites outside of Giza. This would have included the fine limestone used to construct the outside casting of the pyramids and the approximately 80-tonne blocks of granite that form the roof of the burial chamber of Cheops.

Top: From high up on the second pyramid looking west, one can see the galleries where excavation work is in progress.
Bottom: The principal queens and senior royal relatives of Cheops, builder of the Great Pyramid, were buried in this cemetery.

The missing element in all this is the location of the workmen's settlements. By studying the layout of the natural features and existing structures, Lehner came up with a model of the plateau based on a hypothesis of how the site was organized and where the workmen's settlements might have been located. The excavation this past winter was the first chance to test that model.

Lehner and Hawass chose two primary sites for the initial season's work. The first site, designated Area A, lies some three hundred metres south of the Sphinx. It extends several hundred metres beyond a large, 200-metre-long stone wall with a massive gateway. The wall marks the southern boundary of what may have been the ancient harbour. The wall also extends from the mouth of a broad wadi (a drainage channel) that, according to Lehner's model of the plateau, may have been the route through which building materials brought up the Nile from other locations were transported from the harbour to the ramps that led up to the pyramids.

Area A lies in a tract of low desert that is bounded on the west by a large rock outcrop, or butte, from which one can look down to see the wall and wadi and quarries to the north just below the pyramids. "I like to think that the 4th-dynasty Egyptian engineers stood up on that butte and directed from it the movement of materials and workmen to and from the pyramids building site," Lehner comments. "The butte offers the best view of the entire plateau, even today."

Work begins in Area A where, in the 1930s, materials associated with human settlement rather than royal tombs were found.

Archaeological evidence gathered in the 1930s gave Lehner and Hawass even stronger reasons for selecting this site. In 1934 an Egyptian Egyptologist, Selim Hassan, dug test trenches in this area of desert beyond the huge walls, in search of a clean tract of land that could be used for the relocation of a Muslim cemetery belonging to the residents of a nearby village. Hassan reported that in each test trench, digging to a depth of a few metres, he found evidence of mudbrick walls, pottery, flints, and other materials associated with human settlement. "Egyptologists were still primarily looking for royal tombs, art objects, and inscriptions in those days so not much was made of that information," Lehner explains, "but this indicated to me that it was possible that underneath layers of drift sand we might find a substantial settlement."

The second area of excavation, designated Area C, is located just west of the second pyramid of Chephren. There, upon the rocky desert surface, lie collapsed remains of stone rubble walls that make up a great rectangular enclosure approximately 80 metres wide by 450 metres long parallel to the west side of Chephren. Protruding perpendicularly from the west wall of this great rectangle are a series of parallel walls that form comblike galleries, or open rooms, 3 metres wide and 30 metres long. Lines of scattered rock from the crumbled walls, which appear on the surface of the ground, indicate the floor plan of the galleries. But the galleries themselves, which number ninety-one in all, are filled up with sand—as the excavators found out—to a depth of 3 metres.

The team had to dig at Area C in order to investigate a theory that has been repeated as fact in history books written about Giza since the 19th century. In 1883 Sir Flinders Petrie, "the father of modern archaeology," excavated two of the galleries and found fragments of royal statuary. Nevertheless, he concluded that the galleries were the workmen's bivouac. However, Lehner disagrees. "It never made sense to me that the original purpose of these galleries was to house workmen. The structures do not resemble other workmen's settlements from that period, and more importantly, they look more like storage magazines that we also know from other times and places. And I also kept thinking, if workmen had lived there, where were the remnants of their garbage? Petrie thought that four to five thousand workmen might have been housed in these structures, a number that is far short of the estimates of the total number of workers experts think would have been needed to carry out the pyramids' construction."

The archaeological team split into two groups so that work could proceed at both areas A and C simultaneously. After the initial surveying and staking out of test grids, the two teams, aided by some thirty

Egyptian labourers, began the painstaking task of carefully removing and sifting layers of sand and rocks.

Selecting randomly from among the ninety-one galleries visible on the surface in Area C, the team surveyed a grid over the site and investigated thirteen excavation squares. Each test square measured 5 metres by 4 metres, and spanned the width of the galleries. Squares were selected to include the front, middle, and back sections of the galleries.

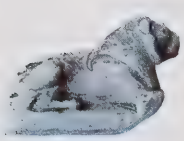
"I put a prehistoric archaeologist, Nick Conard, in charge of supervising the site," Lehner laughs, "and for days he could not get over how much sand was coming out of the test squares. Nick is used to spending weeks and months sifting through small areas of mud and ash in craters of extinct volcanoes in Europe to find tiny bits of bones of animals that were hunted by Neanderthals. For him, the vastness of the site itself, and the quantities of sand and surface debris, meant shifting his focus from small details to the larger task of clearing out the accumulated sand deposits and getting a clear picture of the architecture of the galleries themselves."

The broken royal statue and small lion figurine (facing page) were found on the last days of the excavation.

Most of the galleries, in fact, contained sand that had drifted in and accumulated, undisturbed, over a period of centuries. But unfortunately the artifacts that the galleries might once have contained were removed from them in ancient times. Most of the excavation squares revealed sections with clean, empty floors. Each gallery was similarly constructed and consisted of solidly built, slightly sloping walls made of stone rubble and clay, approximately 3 metres wide at the base and 3 metres tall. The floors were levelled with limestone chips and gravel, overlaid with a paving of mud and clay plaster. The galleries opened southward to a threshold and entrance with doorjambs made of well-laid limestone blocks.

Although Lehner was satisfied with getting a good look at the walls and layout of the galleries that were opened, there wasn't much evidence of what the galleries were used for until the team reached the very bottom of the test squares. Fortunately, because of Conard's meticulous training, clues were found embedded in the floors. A picture of craft storage and production emerged. The clues included materials such as small flint blades and tiny bits of copper, the main materials from which tools were made in ancient times. Also, small sandstone rubbers, commonly used for polishing objects and grinding pigments, and even more exotic materials like feldspar, malachite, and carnelian turned up. These materials, in turn, helped make sense of the many chips of non-local stones such as granite, quartzite, and basalt—exotic stones that were commonly used for buildings and tools in ancient Egypt—that the team found on the surface of the galleries before they began excavating.

A worker in Area A uses a sieve to find small pieces of bone and other artifacts too small to be seen during the excavation.



Three days before the team stopped digging, Conard's team excavated one last square and found an intact ancient deposit on the floor of one gallery. It contained evidence of roofing—reed impressions in mud—which suggested that some, if not all, of the galleries were roofed. The deposit also yielded little bits of sculpture—a lion figurine, a rare figurine of the king wearing the typical conical-shaped south crown, as well as two small limestone statues of the king, one of which, though badly broken, once stood knee-high.

One small limestone piece, which for Lehner confirms that the galleries were once the site of a crafts workshop, is no larger than the size of a thumb. It is a carved figure of the king wearing the ancient Egyptian south crown. The king's face is blank and the ears are only roughly carved, but the head with the south crown is attached at the back to a pillar, and jutting out over the top of the crown there is a projection that looks like a ceiling. The whole piece is stippled black and red to imitate granite.

Lehner described the piece as a conceptual model for one of the large statues made out of granite in the open court of the pyramid temple. The back pillar on the figurine represents one of the pillars of the colonnade in the temple, and the projectile on top of the south crown is the roof of the colonnade.

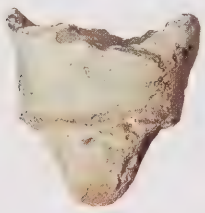
The excavations at Area C seem to have produced enough intriguing bits of evidence to create a new hypothesis much different from the one Sir Flinders Petrie formed a century ago. The galleries were very likely used as storage rooms for materials used in royal craft production at the time that the second pyramid and its temple complex were being constructed. The open areas in front of the galleries may have been where work actually took place on statues and crafts. The absence of any evidence of day-to-day habitation, such as ovens, hearths, pottery, or, as Lehner has pointed out, garbage, make the case stronger that men worked here, but did not live here in large numbers, and so eliminates this place as one of the possible locations of the workmen's city.

Meanwhile, a second team at work at Area A had prepared five excavation squares for investigation. A spot was chosen in the middle of this tract of desert where young boys from the nearby village had hauled away layers of clean drift sand more than 2 metres deep and had exposed tops of ruins—traces of walls, concentrations of pottery, and mud brick. According to Lehner, the village boys were interested in the sand because someone in the village was probably paying them to get it for a local construction project. Their enterprise happened to save the archaeologists a lot of time.

As they excavated, it was hard to see anything distinctly architectural. Lehner de-

scribes the deposits as "one large morass of soil with pottery, animal bones, and charcoal." After careful work with trowels, the team began to make out thin yellow lines in the ground. These lines, which were only millimetres thick, ran parallel and turned ninety-degree corners. As the team began to follow them, they realized that the lines were the plaster facings of walls.

Eventually, the yellow lines began to describe the form of a rectangular building, approximately 6 by 12 metres, running north to south. The walls of the building were made of limestone chips and desert clay, called *tafla* in Arabic, a common building material in ancient Egypt, and were preserved intact only to a height of one metre. The building was divided in two equal parts by a central partition wall. The main feature on either side of the partition wall was a series of rectangular-shaped limestone and clay pedestals, approximately 60 centimetres by one metre. The pedestals were separated by narrow (10-20 centimetre) spaces.



Top: The central partition wall can be clearly seen in the granary building; rows of pedestals are at the rear. **Bottom:** One of the bread moulds found in the building next door to the granary.

In Lehner's words, "The rows of pedestals were a puzzle as the form of the building emerged. Various possibilities occurred to the team. We thought that perhaps we were in the middle of a pillared hallway, which would suggest that we had found a ceremonial building of some kind. Other team members thought the pillars were small markers for tombs."

Eventually, an important clue to the purpose of the pedestals emerged from a building next door—just to the east—which was separated from the first building by a narrow alley. Only a part of this building, made of alluvial mud (mud from the Nile valley floor) was excavated, but inside it the team found hundreds of fragments of a particular kind of pot that was used by the ancient Egyptians for baking bread. The archaeologists recognized the pots from particular relief scenes that they knew in tomb chapels belonging to nobles and various officials of the Old Kingdom at Giza and Sakkara. Sakkara is the site of the cemetery of the ancient city of Memphis that lies 20 kilometres south of Giza.

These scenes show conical-shaped pots arranged in a large pile, sitting atop a fire that someone is tending underneath. After the pots are heated, dough and leaven are prepared and poured into them. The pots serve as miniature ovens to bake the mixture. These "bread moulds," as they are known among archaeologists, are prominent in scenes that also depict beer brewing. Bread baking and beer brewing go hand-in-hand in the Old Kingdom. Tomb scenes show that the Egyptians prepared a

In this scene from an Old Kingdom tomb, grain silos are depicted standing upon pedestals separated by wooden slats in the lower register, and men measure grain in the upper register.

mash for beer into which they dropped small bits of lightly baked bread dough to ferment the liquid. Bread and beer were the main staples of the Egyptian diet, and they were the principal rations given to workers.

The key for the archaeologists was that in these scenes of bread making and beer brewing, there is always a granary nearby. Here the grain for both products was stored in cylinder-shaped, domed silos that were arranged in rows in the middle of both sides of the granary. Overseer of the Double Granary was a common administrative title in the Egyptian state. Some of the Old Kingdom tomb scenes show these grain silos separated by slats—possibly made of wood—as well as sitting atop a small rectangular pedestal. The pedestal served to keep the grain away from rodents and dampness on the floor, and gave height to a sliding door at the bottom of the silo so that the grain could pour down into a receptacle.

Lehner and the others are reasonably certain that their building is a granary. They may also have uncovered part of a bakery, and who knows, the whole of the rest of the bakery-brewery complex may be there too. Bits of textual evidence were uncovered that may relate to the administration of the granary. These are mud impressions of cylinder seals that were marked with the names of Old Kingdom officials and kings. The inscribed cylinders were rolled on wet mud that capped the mouths of jars containing various commodities. All the impressions from the granary complex date back to the time of Mycerinus, the last king of Giza and builder of the Third Pyramid. Lehner and his colleagues hope to find not only more extensive structures, but earlier ones as well that date back to the beginning of the Necropolis—the time of Cheops, who built the Great Pyramid.

Having completed a pilot season to test the notion that workmen's settlements lie in close proximity to the monumental structures that required so much manpower, Lehner and Hawass are eager to return to the site in the coming year to continue the excavations. "These structures can't exist out there alone," Lehner insists. They plan to return to continue the investigation of the granary complex and to explore more extensively the entire tract of low desert, which may be covering settlement for hundreds of metres in the area.

And there is work to be done in the laboratory. The full story of the site will emerge only after hours of analysis of materials that were pulled out of the excavations, such as bone, pottery, and several hundred kilograms of soil samples that contain tiny seeds and other plant remains. These are the bits that will help tell the full story of the site and possibly lead the archaeologists to the city of the workmen who built the pyramids.

The Origins of Urban Canada

Forts have determined urban settlement in Canada to an extent without parallel in other countries

Douglas Fetherling

PHOTOGRAPHY COURTESY THE NATIONAL ARCHIVES OF CANADA

Part of a Palisaded Huron-Iroquois Village by C. W. Jefferys

Jefferys based his sketch on historical and archaeological evidence. *Collection of the National Archives of Canada.*

Northrop Frye's famous remark about Canada's having a garrison mentality has a literal significance quite apart from the metaphorical one he intended. Most Canadian cities grew out of forts erected between the 17th and 19th centuries, a few of which are preserved today as restorations—a great many more of which can be imagined through the reconstructions and recreations (some careful, others not) put up for the tourist trade. Such forts existed for a combination of reasons, by no means all of which were military or even governmental. In fact, Canada's patterns of settlement have been determined, to an extent quite without parallel anywhere else, by private-sector as well as public-sector fortification. Canadian forts were places for doing business quite as often as they were precautions against war or keepers of the peace. That is one of the points easy to forget today. Another is that there was already a strong tradition of fort-building in place when Europeans arrived.

Most people's idea of a fort derives from movies about the Wild West: low buildings surrounded by a tall stockade of logs, placed upright in the ground, one against the next. That was not a current European practice at the time North America was colonized, but it certainly resembled what the Europeans themselves found when they first arrived. Champlain, for example, noted that the native villages consisted of longhouses enclosed in oval stockades. The sites of some of the very ones he mentioned have been examined by archaeologists.

Such investigation generally has shown that the Huron people

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favoured temporary communities of one or two thousand souls, usually on high ground and near water, behind stake-walls as much as 5 metres high. They chose this form of encampment as a defence against their enemies, the Iroquois, who lived south of the Great Lakes and the St. Lawrence. The Hurons were finally dispersed and slaughtered by the Iroquois during the 1640s and 1650s. One of the last stands took place at Christian Island in Georgian Bay where perhaps as many as 4000 Hurons withstood a long Iroquois siege hold up in a crude stone fort with a moat (a site itself the subject of recent excavation work). With them were

A South West View of Prince of Wales Fort, Hudson Bay by Samuel Hearne, published in 1797

PHOTOGRAPHY COURTESY THE CANADIAN DECORATIVE ARTS DEPARTMENT, ROM

some of the Jesuit priests from Ste.-Marie-among-the-Hurons, which is not usually thought of as a fort but which, like Champlain's Habitation before it, was certainly constructed with defence in mind—European-type defence, that is.

In the broadest possible terms, one could say that from earliest times until the 14th century or so, the idea of a fort or fortress suggested a structure that was high in the air—perched so that enemies couldn't climb into it, and allowing its defenders to hurl objects down on them if they tried. With the invention of gunpowder all that began to change. Forts gradually became low instead of tall and wide instead of narrow. They assumed complex geometrical shapes (to view Louisbourg, say, from the air is to be reminded that it flourished at the same time as topiary, the art of shrubbery trimmed in fanciful shapes). No longer was the goal to stay above the attackers but rather to keep them at bay, out of gun shot range, and when that was no longer possible, to trap them in the jigsaw of sharp straight lines, free of blind spots where they could hide from enfilading fire. The principle was

The fort was built by the Hudson's Bay Company between 1733 and 1771 and surrendered to the French in 1782. *Collection of the Canadian Decorative Arts Department, ROM.*

called defence-in-depth: not depth as in distance underground but depth in the sense of recessional distance, as in a photographer's depth-of-field.

The author or refiner of many of these ideas, and the greatest military engineer of his day, with a long list of successful sieges and defences, was Sebastien le Prestre de Vauban, a 17th-century Frenchman, whose influence was immense and universal. His contemporary John Churchill, the first Duke of Marlborough (and founder of the Churchill clan), was a close student as well as an adversary. Prince of Wales Fort, the huge Hudson's Bay Company outpost built between 1733 and 1771 to control the body of water whose name the company bears, is Canada's clearest link to this style, having actually been designed by engineers who had studied Vauban and worked for Marlborough. But with its 9- to 12-metre thick walls, it is only the biggest Canadian example of a particular type of fort: the star fort—so called because it was laid out in the configuration of a star. These forts were set close to the ground, with bastions on each corner shaped like elongated diamonds, and featured complicated arrangements of outerworks, redoubts, and such. Star-forts were adaptable to situations of any size, including the very modest, and were the dominant type of military architecture through the middle of the 19th century. The present-day versions of the Citadel at Quebec (begun 1821), the Citadel at Halifax (1825), and Fort Henry at Kingston (1836) all follow this scheme. Incidentally, the career of Prince of Wales Fort ended with a whimper. In one of the last actions of the American Revolution, Samuel Hearne surrendered it to the French without a shot in 1782, because he didn't have enough personnel (only 39—there was room for 300 or more) to man the cannon. As Peter C. Newman has pointed out, the Hudson's Bay Company was notorious for failing to maintain the defensive posture that it so prudently built into its various posts in the first instance.

To strengthen their fortifications the French employed Canada's first great military engineer, Gaspard-Joseph Chassegros de Levy, a Frenchman who wrote a textbook about fortifications

Of course the fur trade was also the principal reason for the existence of French forts in North America, which could range from the grand design—whole communities in themselves—down to tiny wintering forts with only a handful of soldiers such as first marked the European presence in what is now Toronto. The original version of Fort Frontenac at the future site of Kingston, for example, was thrown up in a week's time in 1673: a small cabin sitting inside a small stockade like a duck in a pond. The key fact about such early forts is that they formed a string along the northward and westward water routes; if they were dots

View of the Champs De Mars, Montreal by R.A. Sproule and W. L. Leney, published in 1830 ***Soldiers drill in the parade square while Indians talk and watch.***

Quebec from the Ramparts after J. P. Cockburn, circa 1830 ***The officer and lady with a dog stand on the wall of the fortification; the lower town is below them.*** *Collection of the Canadian Decorative Arts Department, ROM.*

PHOTOGRAPHY COURTESY THE CANADIAN DECORATIVE ARTS DEPARTMENT, ROM

on a map and one connected them, the result would be an outline of the St. Lawrence and the Great Lakes. They were also the top portion of an elaborate chain linking Canada to French settlement in Louisiana via the Ohio and Mississippi valleys, and were upgraded as the fur trade grew and as they, in consequence, became more conspicuous targets.

Canada's first great military engineer was in charge of one such round of strengthening. Gaspard-Joseph Chassegros de Levy, a French officer who had helped ferry James the Old Pretender across the English Channel in his attempt to reinstate

Fort Chambly by Bouchette

PHOTOGRAPHY COURTESY THE CANADIAN DECORATIVE ARTS DEPARTMENT, ROM

the Stuart monarchy, had written a textbook on fortification, and partly on that basis was sent to Canada by the Department of Marine in 1716 to bolster the defences of Quebec. That done, he built a protective wall around Montreal, using funds raised by the mercantile community there. The wall was 5.4 metres high, about the height of a two-storey building, and had five posterns, or small gates, and thirteen bastions built into it. Since it was built to hug the contours of the existing town, the wall was not geometrically sophisticated, hence not militarily sophisticated either, and could not have withstood a siege of heavy artillery followed by a determined assault. That is one reason Lord Dorchester abandoned Montreal to the American army in 1775 and withdrew to Quebec. But the strength of the works were such that it took twenty-five years to tear them down when they were no longer needed in the early 19th century. One small section was discovered in 1988 by contractors excavating for condominiums on Bonsecours Hill.

Gaspard-Joseph Chassegros de Levy, Canada's first great military engineer, built this thick masonry star-fort. *Collection of the Canadian Decorative Arts Department, ROM.*

Chassegros de Levy's other Canadian projects included one of the many forts that have been erected at Niagara over the years. He also built the second Fort Chambly, the thick masonry star-fort on the Richelieu River south of Montreal. Wooden forts had stood there since 1665. The new one was a necessary response to the British-Iroquois alliance to the south, and it had to be stout

and well-armed to prevent the passage of artillery along the river. It was in use as a fort until 1731 when it became a storehouse, but it wasn't finally abandoned until 1851 (about the time Cornelius Krieghoff painted a view of it that made it seem like an ancient castle on the Scottish border). In 1882, the local farmer who then owned the site got funds from the Dominion government to help restore it. This was a few years after Lord Dufferin, the governor general, had urged restoration of the Citadel in Quebec (and a generation before Laurier, in 1908, created the National Battlefields Commission to prevent the development of the Plains of Abraham). Thus was the movement to save Canada's heritage of military architecture born.

FORT GEORGE WITH THE CITY OF NEW YORK FROM THE S.W. BY I. CARWITHAM, 1731-36 VIEW PUBLISHED AFTER 1764

PHOTOGRAPHY COURTESY THE CANADIAN DECORATIVE ARTS DEPARTMENT, ROM

The warship with smoke pouring from both sides and the fort fly the Union Jack. *Collection of the Canadian Decorative Arts Department.*

Not only did the British conquest of French Canada cause French military architecture to be supplanted by British, it changed the most basic assumptions about the protection of Canada. Any threat now would come not from across the Atlantic but from the south. Responses to this new reality would be as different in scope as Fort York, built by John Graves Simcoe in 1793, and the Martello towers (stout circular artillery batteries) erected in 1800 at Halifax and Saint John to supplement the harbour defences there. The War of 1812 proved the worst fears to be well founded.

The British conquest of French Canada caused French military architecture to be supplanted by British and changed the focus of the protection of Canada from the Atlantic to the south

If the Americans were ever to invade Canada again as they had in 1775-76, it was clear that the attack would probably come across the border in the Niagara region and the lower Great Lakes and perhaps straight up Lake Champlain to Montreal as well. Nothing better illustrates the point-counterpoint nature of British-American relations during the twenty-five years or so beginning in 1790 than the two sunken star-forts facing each other across the Niagara River near its mouth. Fort Niagara, the American one, was within sight of the British one; Fort George was little more than a kilometre away from what is today Niagara-on-the-Lake.

Such a checkmate was not always possible, though the threat remained constant. After all, it was in search of a more defensible place, one in which ships might be built under protection of a fort's guns, that Simcoe withdrew the capital of Upper Canada from Newark (Niagara-on-the-Lake) to York (Toronto), thus occasioning the latter's growth. When the new town and its fort fell to the invaders, shipbuilding shifted to Kingston, where the original Fort Henry protected the dockyards. Virtually every type of fortification was used in the 1812-15 conflict, not excluding the simple blockhouse, such as the one at Gananoque that withstood a fierce attack. Many lessons were learned.

Through most of the 19th century, the Royal Engineers played an extraordinary and still under-appreciated role in Canada, on projects as far apart in time and distance as the Citadel in Halifax and the Cariboo Road in British Columbia. One of the major

challenges they were saddled with was that of establishing a transportation link between Kingston and Montreal that would bypass the St. Lawrence and thus be well out of range of the border with the United States. Beginning in 1819, locks were built on the Ottawa River, followed by the more famous Rideau Canal, two hundred kilometres in all, linking Kingston with Ottawa, which was then called Bytown (after Colonel John By, the superintendent of the project, who had made his reputation during the Napoleonic wars building Martello towers in Quebec). At strategic points, the canal was guarded by blockhouses. One of the four original ones can be seen at Merrickville. Later, during the Oregon Crisis, when it seemed as though a boundary dispute might actually send Britain and the United States to war again, defences at the Kingston end of the system were upgraded, most notably with the construction of the four Martello towers that are such landmarks today. There would be another hurried round of fort-building, particularly at Halifax and at Levis, opposite Quebec City, when the American Civil War flared up ominously.

VIEW OF FORT NIAGARA ON LAKE ONTARIO FROM THE LIGHT HOUSE ON THE BRITISH SIDE, ARTIST ANONYMOUS

View of FORT NIAGARA *on* LAKE ONTARIO *from the* LIGHT HOUSE *on the* BRITISH SIDE

PHOTOGRAPHY COURTESY THE CANADIAN DECORATIVE ARTS DEPARTMENT, ROM

Fort Niagara was the American counterpoint to the British Fort George. *Collection of the Canadian Decorative Arts Department, ROM.*

Martello towers were small but permanent structures (most of them still stand) specifically designed for coastal defence. By contrast, blockhouses were cheaper to erect and altogether less permanent, though the ones at Fort York are probably the oldest buildings in Toronto. The essential feature of a blockhouse was that it had two storeys, with the upper one protruding over the lower, so that those inside could, through apertures in the floorboards of the overhang, fire down on people trying to force their way in. That makes them sound strictly defensive rather than offensive, but since they could be built quickly and inexpensively, blockhouses were frequently of an administrative nature. In

other words, they were sometimes intended to protect the Crown from the people rather than protect the people from the Crown's enemies. Such was certainly the case after the Rebellions of 1837-38, which resulted in a series of blockhouses guarding the main roads in and out of Toronto. We know what they looked like partly because two generations of watercolourists and other artists liked to paint them. The so-called Yorkville Blockhouse, for example, was on a diagonal plan, with the top storey rotated forty-five degrees, so that the whole structure, if viewed from directly overhead, would have given the appearance of an eight-pointed star.

PERSPECTIVE VIEW OF ONE OF THE 3 BLOCKHOUSES, AT TORONTO, CANADA

Blockhouses, like this one near the present-day corner of Yonge and Belmont, were built in Toronto following the 1837 Rebellion. *Collection of the Metropolitan Toronto Reference Library.*

PHOTOGRAPHY COURTESY METROPOLITAN TORONTO REFERENCE LIBRARY

The forts of the fur-trade are a subject too vast even to sketch in so small a space as this. Starting with Rupert House on James Bay, which has recently been the site of archaeological work undertaken by the native community, the trading posts, forts, and factories (terms sometimes used interchangeably) came to delineate the very demography of Canada, particularly, of course, the West and North. If an old map showing the scores of different posts were superimposed on a modern one showing cities west of Quebec, the dots would overlap to a remarkable extent. One architectural point worth noting is that the Hudson's Bay Company often adopted the French Canadian style of log building, with walls made of logs or timbers placed horizontally rather than vertically (*pièces-sur-pièces*).

The raison d'être of fur-trade forts was the protection of the valuable goods inside rather than the need to repel invaders. As a result, they were easily taken and destroyed when trouble arose

Fur-trade forts came in all sizes. Old Fort William, the popular reconstruction at Thunder Bay, gives a pretty good impression of how that huge facility of the North West Company must have looked before the company's merger with the Hudson's Bay Company in 1821. Most of the larger premises were equipped with cannon, though the *raison d'être* of such forts was always the protection of the valuable goods inside rather than the need to repel invaders. As a result, they were easily taken and destroyed when trouble arose, as during the Red River Rebellion, when Louis Riel had no difficulty obtaining the surrender of Fort Garry.

The Mounties developed their own tradition of fortification. The force was created in the Canadian West with a view towards such tasks as dealing with the whiskey traders at places like Fort Whoop-Up, near Lethbridge, a formidable enough structure of log, earth, and sod construction, with stout blockhouses and a little artillery. The Mounties arrived to find it already abandoned but proceeded to build their own Fort Macleod, a rectangular stockade of cottonwood logs 3 or 4 metres high, with one-storey buildings hard against all four inside walls. Fort Walsh in the Cypress Hills and Fort Calgary on the Bow River followed the same pattern. Although beginning with Fort Calgary the Mounties usually used independent contractors, the specifications were roughly the same. The Mounties seemed to favour T-shaped barracks.

The development of guns powerful enough to destroy forts from miles away coincided roughly with the withdrawal of the British military from Canada between Confederation and the turn of the century, but the long pause in fort-building that resulted did not become a complete cessation. Just as gunpowder had made fortification spread out along the ground, so the Bomb made it go underground—from the fall-out shelters to the once-famous Diefenbunker near Carp, where the Canadian government was supposed to carry on in the event of nuclear war. It also produced what might be called electronic forts, from the

FORT WILLIAM BY HENRY SANDHAM

PHOTOGRAPHY COURTESY THE CANADIAN DECORATIVE ARTS DEPARTMENT, ROM

Indians and hunters are trading goods; Fort William is in the background. *Collection of the Canadian Decorative Arts Department, Royal Ontario Museum.*

now obsolete DEW Line to the new North Warning System being built today. Doubtless these posts too will come to have historical significance given enough time.

If that is difficult to believe, remember that the same reaction once greeted suggestions that the old forts from the War of 1812 warranted preservation. The Ontario Historical Society owes much of its momentum to the mobilization effort that was necessary to prevent a streetcar line being pushed through Fort York early this century. In the 1950s the old place had reason to fear the Gardiner Expressway (which, in the end, was built over it—a kind of aerial vandalism). Quite recently, there was the threat that Front Street would be extended to the fort. It is ironic that forts, the foundations of Canadian urban settlement, must continue to fight for their survival or their historical integrity long after their guns have fallen silent. ❦

PHOTOGRAPHY BY CHRISTOPHER VARLEY

Paul Wilson owns The Octagon, an elegant house well known to the residents of Port Hope.

A Home for All: Ontario's Octagons

PERHAPS ONLY 19TH-CENTURY America could have produced Orson Fowler. A gloriously self-confident amateur who pronounced with equal intensity on cranial bumps, excessive sexuality, and the mixing of grout, Fowler was best known to his contemporaries as the champion of a precursor of psychiatry called phrenology. His phrenological writings are now rarely reviewed historical curiosities, but Orson Fowler also left monuments, which stretch from New York to British Columbia, including at least three dozen still standing in Ontario. They are octagonal houses, structures Fowler firmly believed would create good character and lower heating bills as well as bring domestic felicity to every working man's family.

Fowler found his way to octagonal houses more or less naturally via phrenology, an enormously popular pseudo-science that judged character by examining the cranium. Heads were mapped out in terms of faculties, and the sites of swellings and depressions, indicating the size of mental "organs," were carefully noted. Fowler fingered the skulls of statesmen, criminals, artists, and thousands of ordinary citizens; not surprisingly, rapists were often found to be overdeveloped in the site assigned to "amativeness," as the Victorians called the libido, while devoted family men had superbly mature "organs of adhesiveness."

Some bumps interested Fowler more than others: his book *Amativeness: or Evils and Remedies of Excessive and Perverted Sexuality* was a best-seller. Two other qualities, each with its own location on the cranium, had a special appeal for Fowler—"constructiveness," the love of building, and "inhabitiveness," the desire for a home. Convinced that these traits were crucial to human happiness, Fowler turned his attention to domestic architecture and in 1848 he published another book: *A Home for All or a New, Cheap, Convenient, and Superior Mode of Building.*

Although Fowler claimed that his chosen form, the octagonal house, was "WHOLLY ORIGINAL" with him, architects since the Greeks had occasionally experimented with eight-sided buildings. The Tower of the Winds or Horologium in Athens, the Baptistry in Florence, and the Chapter House of York Cathedral are public examples. When Thomas Jefferson de-

signed his summer house in Bedford County, Virginia, in 1806, he not only chose an octagonal form for the house itself but garnished it with two octagonal privies.

But these pre-Fowler octagons were comparatively rare. Fowler's passion for the form was so contagious that more than a thousand octagonal houses, barns, churches, and schools were built in the United States. New towns entirely devoted to octagonal buildings were planned. In Canada, the octagon spread from St. John's to Vancouver, with the greatest concentration in Ontario and the smallest in Quebec and the Prairies. Although the craze for octagons declined after 1860 in the United States, conservative Canadian builders continued to build them into the 1880s.

Certainly Fowler's considerable prestige as a phrenologist helped to make octagons popular. But *A Home for All* brimmed over with theories about the form's perfections, aimed so skilfully at the pragmatic as well as the most feverishly idealistic attitudes of mid-century America that its success was virtually inevitable.

First, Fowler claimed it as "a fixed ordinance of Nature" that the most aesthetically pleasing forms were spherical. "Why," he asked, "is it that a poor animal, or a lean person, is more homely than the same animal or person when fleshy? Because the latter are less angular and more spherical than the former." Not only were circular forms more beautiful, but they actually caused good feelings: "To gather around a spherical or elliptical table, occasions more harmony and agreeable sensations than around a square one." Since Nature had created ten thousand curvilinear forms for each square one, it seemed only reasonable to Fowler to look for the housing form that most closely approached the spherical—the octagon.

Aside from the octagon's share in the circle's rather mystical powers, it promoted harmony because it was the most convenient house

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imaginable. (As Fowler noted, everything in Nature is beautiful, but it is never merely beautiful.) Since the majority of octagons were organized around a central hall and stairwell, the rooms formed an interconnected chain around the periphery of the house. Unnecessary steps were minimized, more air and light entered the rooms, heat was conserved, and—if Fowler is to be believed—the national character was perfected. He painted a grim picture of life in a non-octagonal house:

How much fretfulness and ill temper, as well as exhaustion and sickness, an unhandy house occasions. Nor does the evil end here. It often, generally, by perpetually irritating mothers, sours the temperament of their children, even BEFORE BIRTH, *thus rendering the whole family bad-dispositioned* BY NATURE, *whereas a convenient one would have rendered them constitutionally amiable and good.*

Fowler's concern for the hard-working housewife, as opposed to the women he scorned as "parlor toys," was typical of his era. Yankee notions of self-sufficiency and ingenuity, combined with the difficulty of keeping servants in a democratic society, had fostered an interest in "domestic economy" and labour-saving devices of all kinds. The novelties Fowler incorporated into his own octagonal house in Fishkill, New York, included closets, hot and cold water on each storey, filtered rainwater for drinking, and an indoor toilet under the stairs. (The last was intended only for "matrons, the aged and feeble." As for the excrement deposited in the usual outhouse, Fowler devised an elaborate plan for converting it into liquid fertilizer that could be used for the family's grape vines and vegetables.)

An octagonal house was more than a building: as modern advertisements would put it, it was a lifestyle. The lifestyle, a Fowleresque blend of pseudo-science, wholesome living, and startlingly modern conveniences, left its mark on many octagon owners. Ontarians were no exception. The octagon built in 1856 by mill owner William Barrett on Martha Street in Port Hope boasted the town's first indoor bathroom. The several bathrooms in an octagon, now demolished, which stood on Dundas Street in London, reportedly enthralled visitors to the church socials held there. In 1882, when Henry James Bird of Bracebridge built one of the largest octagons in the province, called Woodchester, he installed indoor plumbing, ventilating shafts, water-pressure tanks, and speaking tubes for communicating with the servants. (The presence of *A Home for All* in an octagon's library suggested a commitment to Fowler's principles: Henry Bird had one, as did Reuben Scott, an iron founder who built an octagonal house for his family of fourteen on Parliament Street east of

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Colborne.)

The virtues of modern plumbing are no longer controversial, but the actual convenience afforded by the octagonal form remains debatable. And there may be an interesting sex difference here: in the case of the many-bathroomed London octagon, the builder's son remembered it as an easy house to work in, while his sisters had the opposite impression. Ask Kay Wilson, who has lived in the Port Hope octagon since 1972, about its convenience and she'll smile vaguely and murmur something about the lack of privacy when all the rooms are interconnected. Her husband Paul notes approvingly that there are few corners in which to hide things and insists that the house is "handy as anything."

Fowler's original purpose had been to provide comfortable houses for the poor, and he drew up a remarkable budget whereby a working man could afford his own octagon by living on a pound of wheat and a few sweet apples a day. But Fowler's humanitarian ideals struggled with and ultimately lost to his grandiose desires. He was particularly insistent on the necessity for large bedrooms, writing: *In your small room you are obliged either to breathe your air over and over again for the twentieth time every night, or sleep with the wind blowing directly on you. And if two occupy the same bed, how doubly bad in the small, and good in the large one.* His own three-storey octagon had sixty rooms, many of them large and reserved for a single purpose—a prophet's chamber, a gymnasium for women, and a room where both "sedentary fashionables and confined operatives" could have private dancing parties.

No octagonal house in Ontario approaches the magnificence of what was called "Fowler's Folly," but very few are workers' cottages. The majority are spacious, middle-class houses, like the one built by mill owner Owen Roblin in Ameliasburgh (Roblin's mill has been

moved to Toronto's Pioneer Village), or the sturdy Congregational parsonage built in 1864 at 48 Division Street in Bowmanville. When the founder of Kingsville, Colonel James King, built an octagonal house in 1856, he spared no expense when it came to stylish interior mouldings and fine French doors. And The Octagon, as people in Port Hope refer to the Wilsons' twelve-room house on Martha Street, manages to be both elegant and strikingly original. Its chief distinction is its large, square central hall with a diagonally placed oval stairwell. Light pours in from an octagonal lantern with stained glass quatrefoil windows around the sides and a skylight at the top. But this house is full of even more thoughtful touches, from the ornate plasterwork and marble fireplaces to the raised verandah with French doors that surrounds the house on six sides.

Several Ontario octagons have lost their original shutters and verandahs, and this tends to give them a stark, drumlike appearance. It also emphasizes their building material, which in many cases is a utilitarian mixture of sand, gravel and lime called grout or gravel wall. When Fowler discovered grout, after publishing the first edition of his book, he revised his text and called the 1853 edition *A Home for All or The Gravel Wall and Octagon Mode of Building New, Cheap, Convenient, Superior and Adapted to Rich and Poor.* Although Fowler hailed grout, which was cheaper than brick and wood and ideally suited to the octagonal form, as "Nature's building material," it does give a depressingly workaday face to many octagons.

At least two of Ontario's octagons have found other uses. The steeply gabled house built by Richard Tennant in Mount Pleasant in the 1850s is now a restaurant. And in Bracebridge, Henry James Bird's pride and joy, Woodchester, has been converted into a museum.

But most octagons continue to serve as private houses, and Orson Fowler may have been on to something after all. It may be connected with the magical properties of the sphere, or the linked traditions of idealism and pragmatism in the octagon's past, but people who live in octagons seem very content with their housing. Cora Greenfield, who was born in 1909 in the Colborne octagon built by her grandfather Reuben Scott, says she would happily live there again. And when Paul Wilson, the owner of Port Hope's Octagon, is asked whether he would choose to live in another octagonal house, he answers firmly, "I wouldn't move out of this one."

KATHERINE ASHENBURG *is arts and entertainment editor for the Toronto* Globe and Mail *and a frequent writer on Canadian culture for several publications.*

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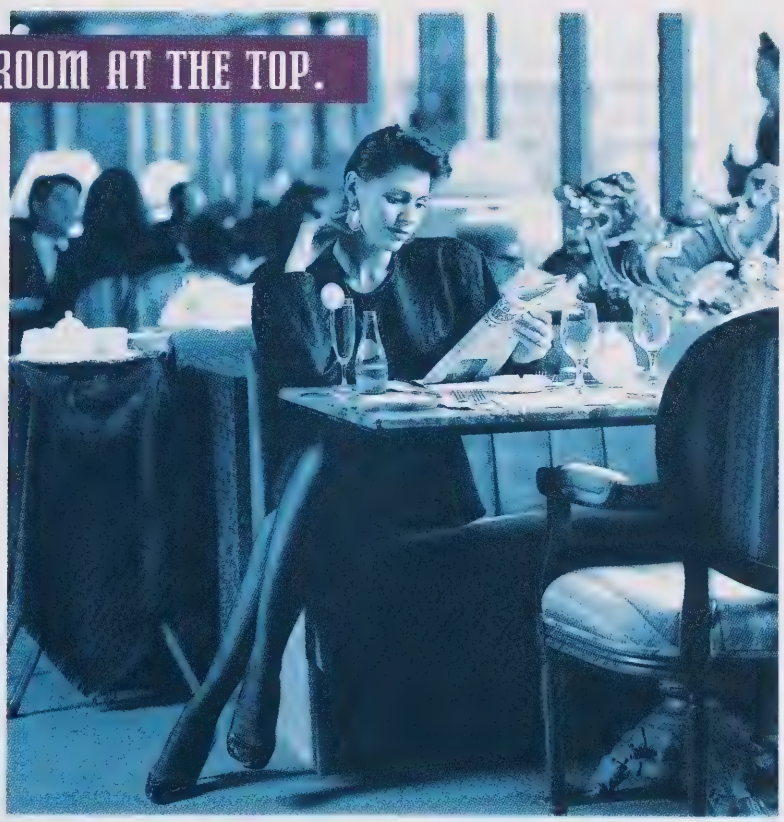

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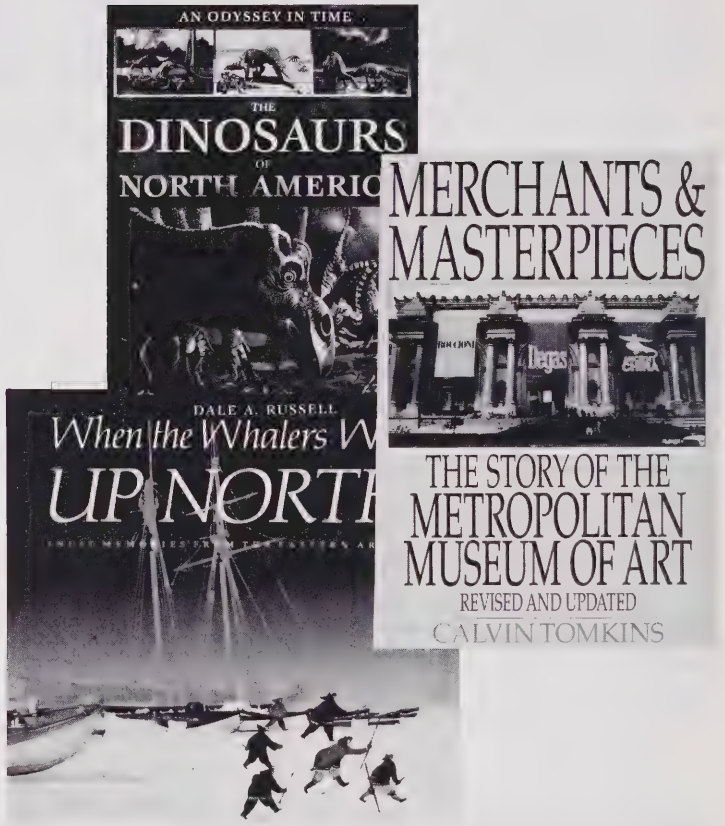


An Odyssey in Time: The Dinosaurs of North America
Dale A. Russell
University of Toronto Press
240 pp. $45.00 (cloth)

THIS MOST RECENT ADDITION TO the vast array of dinosaur books is definitely innovative. Given the title of the book, the reader would expect the bulk of the text to be a systematic description of dinosaurs; however, this is not the case.

A short preface subtitled, "Who Cares about Dinosaurs?", is followed by a brief chapter, "Before the Mesozoic," in which Russell introduces the geological time scale and describes the biological evolution prior to the appearance of the dinosaurs. The remaining seven chapters are organized by geological time period. Although each chapter includes descriptions of the major dinosaur types of each period, the main emphasis is the ecology and environment in which these creatures lived.The book closes with chapters on extinction and the meaning of dinosaurs.

Given the emphasis on the environments in which dinosaurs lived, perhaps a more accurate title for the book would be "The Ecology and Biogeography of the North American Mesozoic." There are numerous photographs of remote and exotic environments existing today, which are thought to most closely resemble ancient Mesozoic landscapes. As well, there are many photos and descriptions of present-day dinosaur-bearing rock strata and the bones discovered within them. Although there are far fewer illustrations of dinosaurs than one might have expected, there are fifteen wonderful, previously unpublished paintings by Eleanor

Kish, Russell's artistic collaborator at the National Museum of Natural Sciences in Ottawa. An extensive bibliography of academic texts and a classification of dinosaurs round out this book.

Russell is also innovative in his avoidance of the daunting names often attached to extinct organisms. He has coined descriptive terms such as cowturtles and owliguanas, which are a blend of the names of more familiar animals that best represent the mixture of characteristics found in these extinct groups.

Nevertheless, most of the book is academic. *An Odyssey in Time: The Dinosaurs of North America* is unique and valuable for effectively bringing together a great deal of disparate information, and as such it is an indispensable source for scholars and others with a special interest in dinosaurs. For the general reader, however, the text may be, at times, difficult to follow.

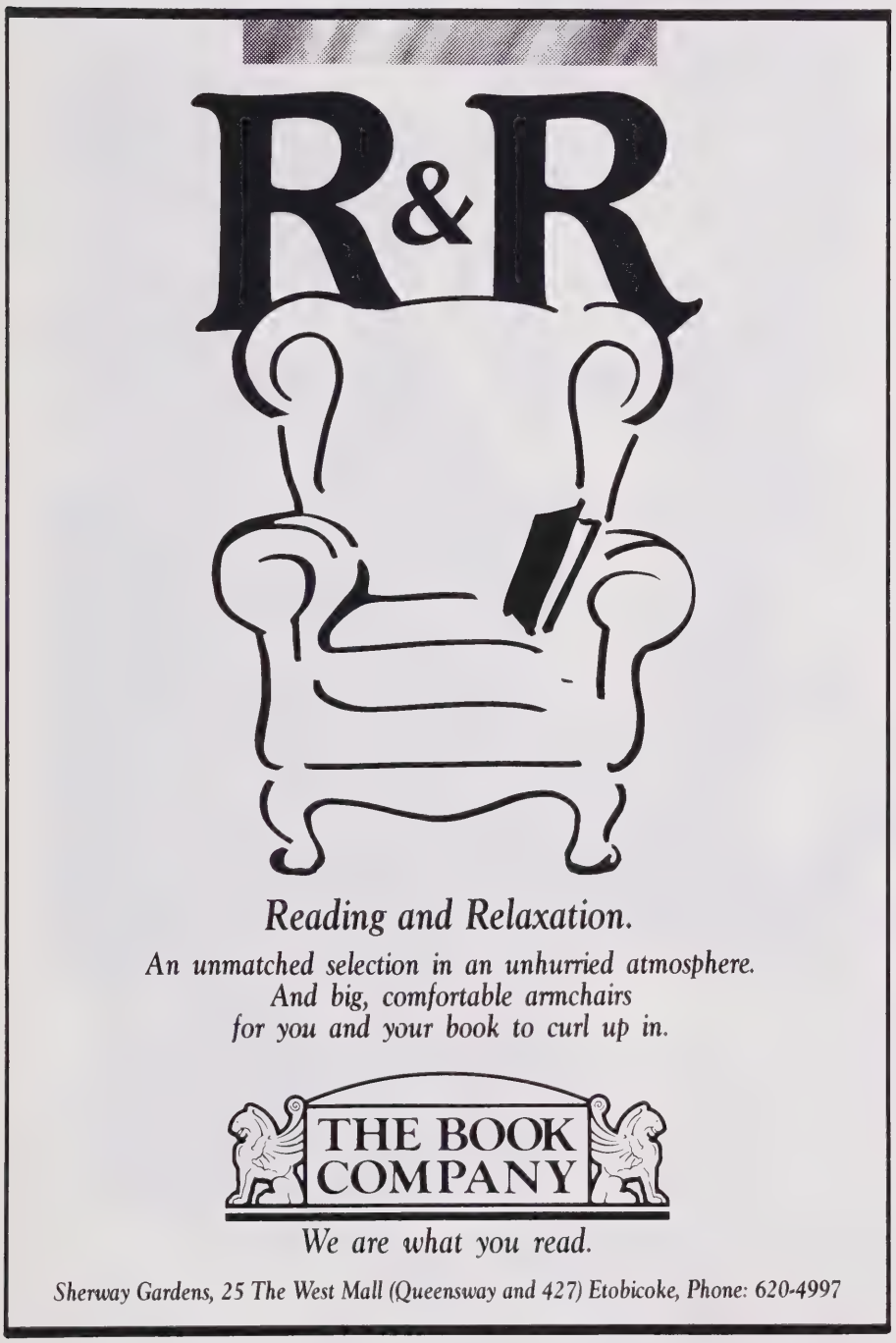
Reviewed by KEVIN SEYMOUR, *curatorial assistant, Department of Vertebrate Palaeontology, Royal Ontario Museum.*

Merchants and Masterpieces
Calvin Tomkins
Fitzhenry & Whiteside
415 pp. $34.80 (cloth)

I COULD NOT EVEN GUESS THE NUMber of times that a staff member of the Royal Ontario Museum has emerged shaken from some momentous upheaval in the Museum and suggested to me that the event was the stuff of novels. My response has always been that few besides ourselves would follow the story to the end. Calvin Tomkins's *Merchants and Masterpieces* gives the lie to my answer. In 1970 he told the tale of the Metropolitan Museum of Art in New York from its founding. Now, in this revised edition, he has added the story of the past two decades.

Written with an investigative reporter's keen sense of the structure behind the façade, Tomkins's tale reveals in detail the Met's numerous knots, splits, twists, and rotted members. The work's somewhat jocular tone suggests a jovial delight in laying the place bare for all to see. Nevertheless, the account of successes and failures, strengths and weaknesses, probity and shadiness, and most of all personal foibles is remarkably evenhanded and free of malice towards those who in some cases clearly deserve it. It would be wrong to apply the trite phrase to Tomkins's work and say that it breathes life into the institution; the life is there, insuppressible, bubbling out of every crevice even when Met officials would probably prefer that it did not. It is much to Tomkins's credit that the life wells up out of the pages even for the reader who does not know the institution.

Anyone who finds museums fas-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Reviewed by DAVID PENDERGAST, *curator in charge, Department of New World Archaeology, Royal Ontario Museum.*

When The Whalers Were Up North: Inuit Memories from the Eastern Arctic
Dorothy Harley Eber
McGill-Queen's University Press
216 pp. $29.95 (cloth)

THE ANCESTORS OF THE INUIT WERE skilled whalers; they were the first people to systematically hunt the large bowhead whales of the North Atlantic and Arctic oceans. When American and European whalers began to penetrate the eastern Arctic during the last century, they found a people whose skills and knowledge they respected and used. The captains of individual whaling ships formed alliances with Inuit family groups that benefited both Whites and Inuit for a period of several generations. The Inuit provided local expertise, and hunted whales on contract in return for whaleboats, guns, metal tools, and other products of the 19th-century industrial world.

Today the Inuit consider the time of the whalers as a golden past, when they were an independent people living on equal terms with the White whalers who were their intermediaries to the rest of the world. Dorothy Eber paid numerous visits to many of the small communities of Baffin Island and Hudson Bay, where she stimulated people's memories of the whalers by showing photographs from museums and archives, recorded the oral traditions of local historians, and collected drawings and prints related to whaling and memories of whaling. She then had a great number of the personal reminiscences and stories carefully translated to form the nucleus of this book.

The Inuit tales are well arranged to tell a lively and intriguing story. They are placed in the context of whaling history as it is known from American and European records, and they provide a surprisingly rich commentary on that history. The text is supplemented by an excellent selection of 19th- and early 20th-century photographs (by both White and Inuit photographers) and by recent Inuit graphic art.

When The Whalers Were Up North: Inuit Memories from the Eastern Arctic will be enjoyed by anyone interested in the Arctic or in northern history. It is also welcome and important material for historians of the Inuit and of the whaling era in the eastern Arctic.

Reviewed by ROBERT MCGHEE *of the Canadian Museum of Civilization.*

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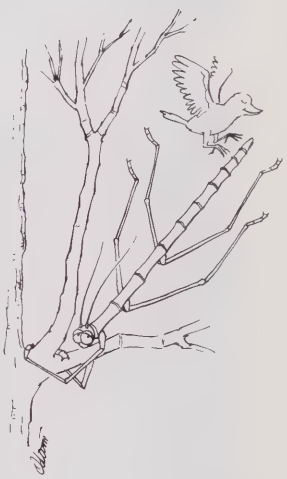
JAY INGRAM

Sticks and Stones

1. Less than ten years after the French Revolution, French engineers discovered what is probably the most famous stone in history. What is it, where did they find it, and why is it important?

2. Stick insects are those strange creatures that look exactly like dry twigs. Some of them are more like branches, considering they are the longest insects known (up to 13 inches, or 33 centimetres long). Besides the obvious camouflage, they employ both "thanatosis" and "repugnatorial glands" for defence. What are those?

3. Skipping stones is one of the pure joys of a day at the beach. Everyone knows you have to use flat stones, and you have to throw them sidearm, but how do stones skip across the water?



4. "Stick and slip" or "stick-slip" is a technical term that describes how some objects move irregularly when rubbed against each other. Common examples include the creaking of a door, and the squealing of car tires. But stick-slip is the mechanism by which a group of orchestral instruments creates musical sound. What are those instruments?

5. Easter Island is the remote volcanic island in the Pacific where a thousand or more grotesque stone statues are found. Some of them are huge—10 storeys high, 75,000 kilograms in weight—but what's most striking about them is their distortion of the human figure. The earlobes and the tip of the nose are greatly enlarged, and the lips are unusually pursed. In an unorthodox piece of analysis, a Harvard psychiatrist has suggested that the statues were built in response to an epidemic of leprosy. What would be the connection?

THE ANSWERS

1. The Rosetta stone, the object that made possible the translation of hieroglyphs. The French government had sent an expedition of soldiers, scholars, and scientists to Egypt (under the leadership of Napoleon) in May 1798 to record and describe the wealth of ancient treasures in that country. Ironically the Rosetta stone was discovered by engineers who inadvertently exposed it in the course of building fortifications near the town of Rosetta (or Rashid).

The stone is a big chunk of black basalt dating from 196 B.C., covered with engraved texts in two languages, which are written in three scripts. The languages are Greek and Egyptian, but the latter is written both in hieroglyphs, the ancient pictorial form of Egyptian, and demotic, a much more modern written form. Happily, all three addressed the same subject, a decree in honour of Ptolemy V Epiphanes, King of All Egypt, yet the decipherment of hieroglyphics still took more than twenty years and included contributions from several researchers, some of them bitter rivals. The great English physicist Thomas Young, who is best known

for his theories on the nature of light, was an early contender, but Jean-François Champollion is the man given the somewhat clumsy title, "Father of the Decipherment of Hieroglyphs."

2. "Thanatosis" is the technique of feigning death or, more properly in this case, pretending to be an inanimate object. Just looking like a twig isn't enough—a moving twig would be noticed immediately by predators. So most stick insects are completely inactive during the day, so much so that the insect's leg, if grasped and moved, will, at most, slowly return to its original position. Sometimes the legs can be placed in unnatural positions and will remain there—as one entomologist put it—"as though the joints were made of wax." Thanatosis is so complete that one researcher reported that "drastic surgery can be performed without causing arousal." To complete the deception, stick insects will hang on to a branch with only their front legs, and rock to and fro in the breeze, even falling like a dead twig if brushed. Stick insects can also change colour to match their surroundings, sometimes quickly enough to match a change from shade to sunlight.

The "repugnatorial" glands, as you probably guessed, squirt a sharp-smelling corrosive liquid that can traverse considerable distances. These are the defence of last resort.

3. The "Amateur Scientist" column in *Scientific American* magazine followed this controversy for more than ten years. In 1957 a retired English professor, Ernest Hunter Wright, wrote the magazine and claimed that his observations suggested that skipping stones did not travel in a series of successively shorter leaps, as you might expect. He tried skipping stones on wet sand, and saw that the length of the skips alternated: short, long, short, long, and so on. The differences were significant, ranging from long skips of several metres to short skips of seven to ten centimetres. Dr. Wright assumed this happens in the water as well. Eleven years and ten thousand letters later, a student at Amherst College, Kirsten Koths, performed his own experiments to show what really happens.

Using a stroboscope (with a flash so fast that it lasted only as long as it would take a car travelling 100 km per hour to travel a distance equal to the thickness of its paint) and polished sandstone discs, Koths found that stones thrown on sand did indeed alternate short and long skips. The first short skip is the result of the trailing edge of the stone hitting first, followed by the leading edge a very short distance further. Often the stone then rights itself and a long hop follows. But a stone skipping on water does not behave the same way. If the trailing edge makes contact first, the stone planes along the water's surface, then starts to tilt

THE INUIT AND HEBRAIC SCIENCE

When The Whalers Were Up North

Inuit Memories from the Eastern Arctic

Dorothy Harley Eber

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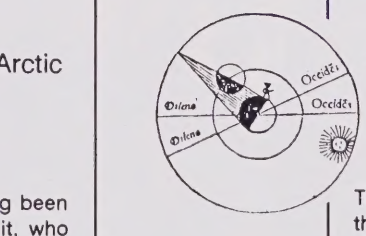

Planets, Potions, and Parchments

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B. Barry Levy

This exhibition catalogue will be published for the Jewish Public Library's Summer 1990 exhibition at the Stewart Museum in Montreal. More than 200 rare scientific manuscripts, books, maps, amulets, and magical texts will be brought together from many famous collections in Europe, Canada, Israel, and the United States. Most are illustrated here.

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backwards as a wave begins to build up at the front of the stone. The stone may then slide up and off the wave, becoming airborne again, provided the angle of the throw is right. The harder the throw, the better the angle; and the flatter the stone, the more likely it is that the stone will skip repeatedly.

4. The strings. Stick-slip occurs when two objects are in contact and a force is applied to one of them. Static friction between the two surfaces at first resists movement, but finally is overcome by the force, and the two objects begin to slide against each other. That change of position reduces the force, and friction stops the movement again. A bow moving across a string first sticks, pulling the string out of alignment. (Putting rosin on the bow ensures enough stick.) Then friction can't hold it any longer, the string slips back, the bow catches it once more, and the whole cycle begins again. The great physicist Hermann von Helmholtz described it best in his 1860 paper on the subject: "The string is carried on by the bow. Then it suddenly detaches itself and rebounds, whereupon it is seized by other parts of the bow and again carried forward." Von Helmholtz showed that at any moment the string has the shape it would have if you pulled it sideways with your finger.

Yet if you look at a vibrating string there is no sign of a sharp bend—instead it seems a blur, narrow at the ends and widest in the middle. That's an illusion. What's actually happening is that the sharp bend is racing along the string, back and forth, pulling it first out in one direction then in the other. The blurred ribbonlike appearance is the path of that bend in the string—you never see the bend itself because it completes one circuit in every vibration.

5. The statues are essentially representations of leprosy in reverse. The protruding parts of the ears and the nose are destroyed by the disease, but they are unusually prominent in the statues. Leprosy can paralyze the facial nerve causing the mouth to hang down, but the mouths of the statues are pursed. Lepers may lose the tips of their fingers, but the Easter Island figures have extremely long, graceful fingers. Dr. Annelise Pontius at the Harvard Medical School was struck by the fact that these statues exaggerated the very tissue that leprosy attacks, and no others. She suggests that Easter Island's extreme isolation may have made it impractical to banish lepers, so the residents sought to undo the disease in a magical way, by emphasizing in stone that which was being lost in the flesh. There is unfortunately no way of knowing whether leprosy might have hit the builders of the statues on Easter Island, although the disease was present on other South Seas islands.

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